POWER

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"Circumstances Alter Cases"

AS THE ENGINEER APPEARS TO THE OWNER WHEN HE SUGGESTS MEANS OF IMPROVING THE PLANT

AS THE ENGINEER APPEARS TO THE OWNER WHEN ANYTHING GOES WRONG WITH THE MOTIVE POWER

Power Plant of Woolworth Building

By Thomas Wilson

SYNOPSIS—Six water-tube boilers of 2454 hp. capacity supply steam to four tandem-compound generating units, which furnish electrical energy to thousands of lights, 27 traction elevators, motors on the ventilation and for other purposes, and exhaust steam for 104,000 sq.ft. of radiating surface supplied by a return-line vacuum system. Features are the provisions for safety on the elevators and the partial condensation of steam from the free exhaust. The remaining vapor is passed into the smoke flue and from the exterior no steam is visible.

The world's greatest office building, the Woolworth, rising 910 ft. above bed rock, or 780 ft. above the curb, is without question the most impressive architectural structure in New York or any other city. With an exterior of creamy-white stone and terra cotta it is visible miles from the city and at night the lighting features are specially attractive. Throughout the main part, the design is a combination of Italian, French and modern Renaissance with Gothic steeples at the roof. Marble of many varieties, steel, bronze and wire glass trim the interior, and in the arcade the design and decorations are magnificent.

Fig. 1. The Woolworth Building

For a building of such mammoth proportions a few popular figures concerning the construction may be of interest. When it is considered that 24,000 tons of steel, 17,000,000 bricks, 50,000 cu.yd. of sand, 15,000 cu.yd. of broken stone, 7500 tons of terra cotta on the exterior and 28,000 tons on the interior for partitions, etc., 53,000 lb. of bronze and iron hardware, 383,325 lb. of red lead, 3000 hollow steel doors, and over 3000 exterior windows were used, some idea of the work involved may be obtained. There are 87 miles of electric wiring, 43 miles of plumbing pipe, 12 miles of marble trim and 12 miles of slate base.

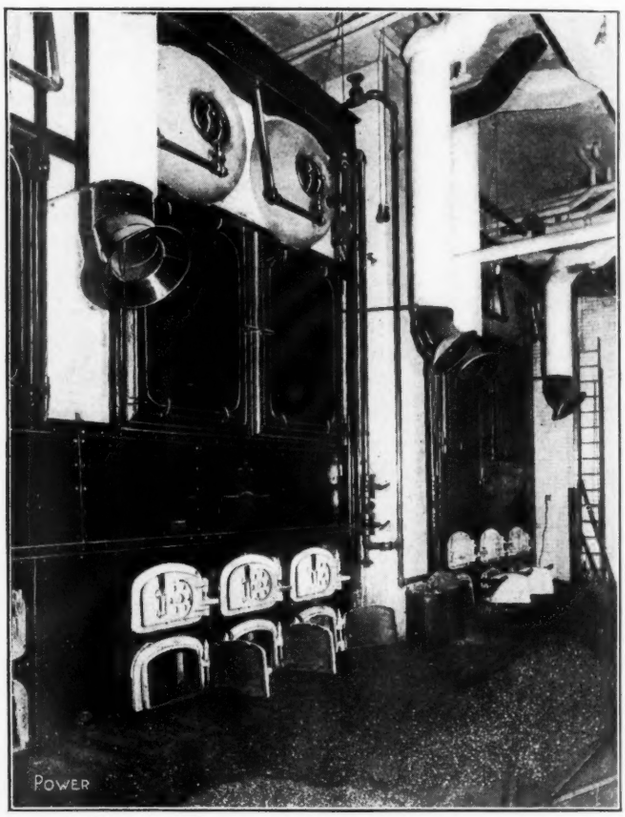

Fig. 2. One Side of the Firing Alley in the Boiler Room

The main part of the building has a base area of about 153x197 ft. It is 29 stories high and its contents is 13,200,000 cu.ft. The tower is 84x86 ft. and its top floor is the fifty-fifth story above the curb. In acres the rentable office space totals 27, and elevators and corridors take 13 more. The total weight at the caissons is 206,000,000 lb. and the cost of the building completed, about $13,000,000.

The plant apparatus installed for the purpose of furnishing power, light, heat, ventilation and refrigeration for this magnificent building represents good office-building practice. The arrangement, as seen by the accompanying plan, is compact and convenient. The appurtenances and piping constituting the central plant are, so to speak, woven in among the foundations and construction work supporting the gigantic superstructure. An impression one receives when first entering the sub-basement is that too little space has been allotted for the mechanical equipment, but this impression is gradually removed when the visitor stops and observes that there is a space for

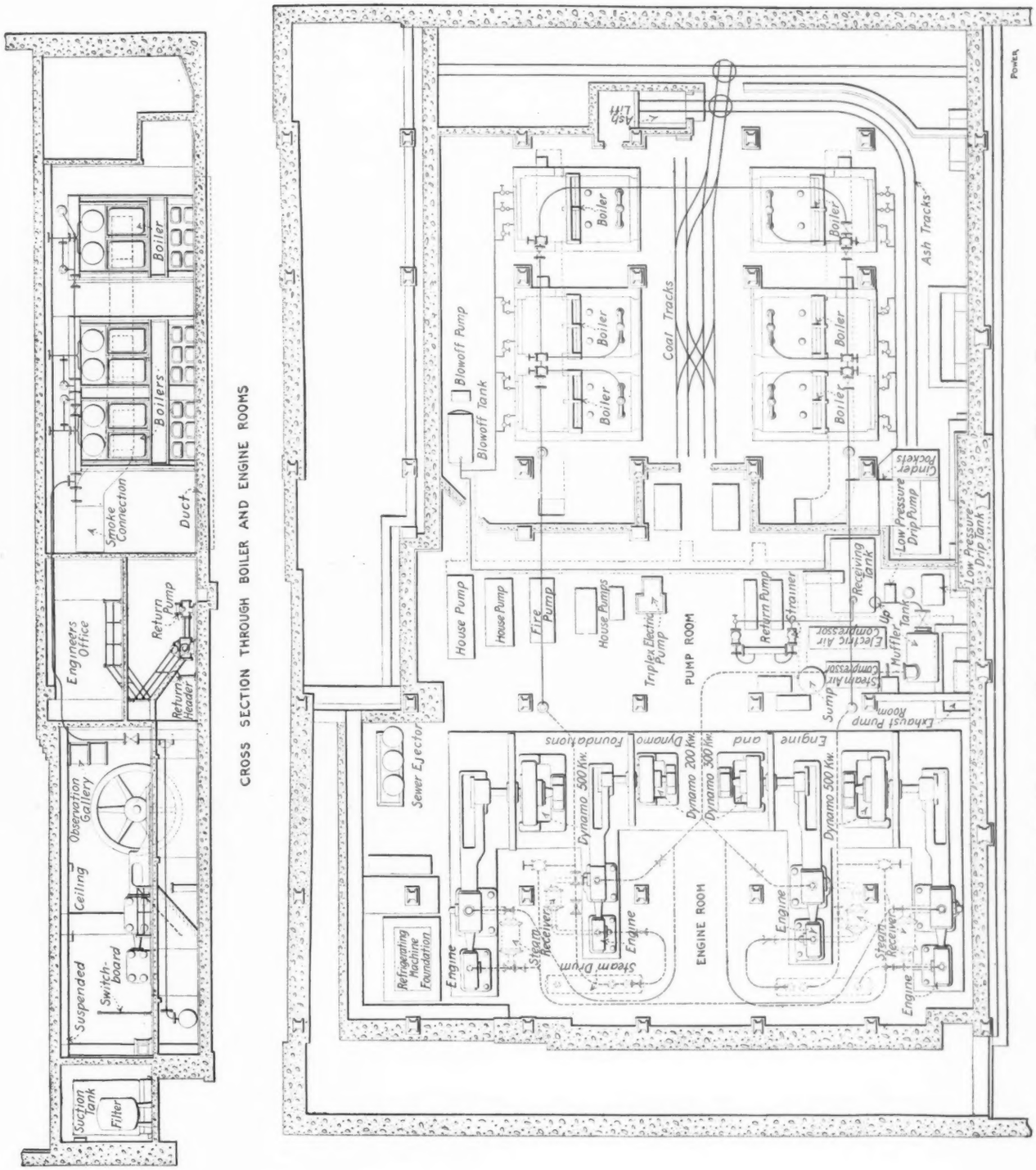

FIG. 3. PLAN AND ELEVATION OF ENGINE AND BOILER ROOMS

everything and everything is in its place in a manner which permits both inspection and repairs when needed, and affords an unhampered freedom for effective operation.

THE BOILER PLANT

Six B. & W. boilers, rated at 2454 hp. capacity, are installed and equipped to generate steam at high pressure. The boilers have wrought-steel headers and each is composed of two 42-in. steam and water drums, one wrought-steel mud drum and a set of tube sections having 12 tubes each, 4 in. in diameter and 18 ft. long. Four of the boilers are built up of 16 tube sections and two have 18 sections. The four 16-section boilers are set in batteries of two, and the wider boilers are set singly. The boilers are suspended on steel framing independent of the brick settings. Provisions are made in the settings for forced-blast installation, and the boilers are so hung that mechanical stokers can be installed whenever such will be required to burn bituminous coal. For the present Treadkill dumping grates are provided and the boilers are hand fired with anthracite coal.

The smoke flue is 6 ft. 6 in. in diameter and over 700 ft. high. It terminates in one of the corner towers where the products of combustion are discharged through openings around the peak of this tower. These openings are

worked into the design in such manner that they are invisible from the street.

The draft is powerful on account of the great height, and as a special means for preventing an undue amount of ashes and cinders from being carried up and discharged into the atmosphere, as frequently is the case in high buildings, settling chambers are provided in the horizontal smoke connections in the sub-basement. There are two of these settling chambers or pockets, one for each side of the boiler room. Each pocket is in the form of an enlargement of the smoke connection, in which V-shaped baffles are suspended, against which the cinders are cast by the force of the draft and thus intercepted and caused to settle down into the bottom pan of the pocket, from which they can be readily removed.

In connection with the disposal of the products of combustion there is also another and distinctly novel feature in the way in which the steam from the free exhaust pipe is made to disappear. The principle is as simple as it is effective, and fails only at such intervals when the draft is checked by the damper regulator. The exhaust steam is discharged to the atmosphere with the hot chimney gases, with the result that the steam is made invisible as long as there are flue gases of sufficient heat and volume. The mixing of the two products is accomplished at the forty-sixth story, where the smoke flue and the free exhaust both had to be transferred horizontally on account of structural features. The exhaust steam is in this story passed through a condenser tank somewhat in the form of a return-tubular boiler, over the shell and through the tubes of which air is drawn by a fan for the purpose of condensing as much of the steam as possible, the remaining vapor being passed directly into the smoke flue and mixed with the chimney gases in their transit to the atmosphere.

The coal storage is located below the sidewalk and has a capacity of 750 tons. The coal is brought to the boilers in charging cars run on an industrial railway. The ash hoist is located on the same side, and the ashes from the boilers as well as the cinders from the settling chambers are taken in barrels on flat top cars to the ash lift and raised to the sidewalk.

Boiler-Room Auxiliaries

The auxiliaries to the boiler plant are situated in the two-story pump room immediately adjoining the boiler room, and between it and the engine room. Here, at the boiler-room level, are located two 12 and 7½ by 15-in. Worthington horizontal feed pumps, of the outside-packed plunger pattern; the house and fire pumps, five steam and one electrically driven; two steam-driven sump pumps; one steam and one electric air compressors for the sewage ejectors; the muffler tank for the 22-in. main exhaust line from the generator engines; the low-pressure drip tank and pump, the two vacuum-return pumps and the receiving tank for the returns from the heating system. The blowoff pump with its tank is located in the boiler room.

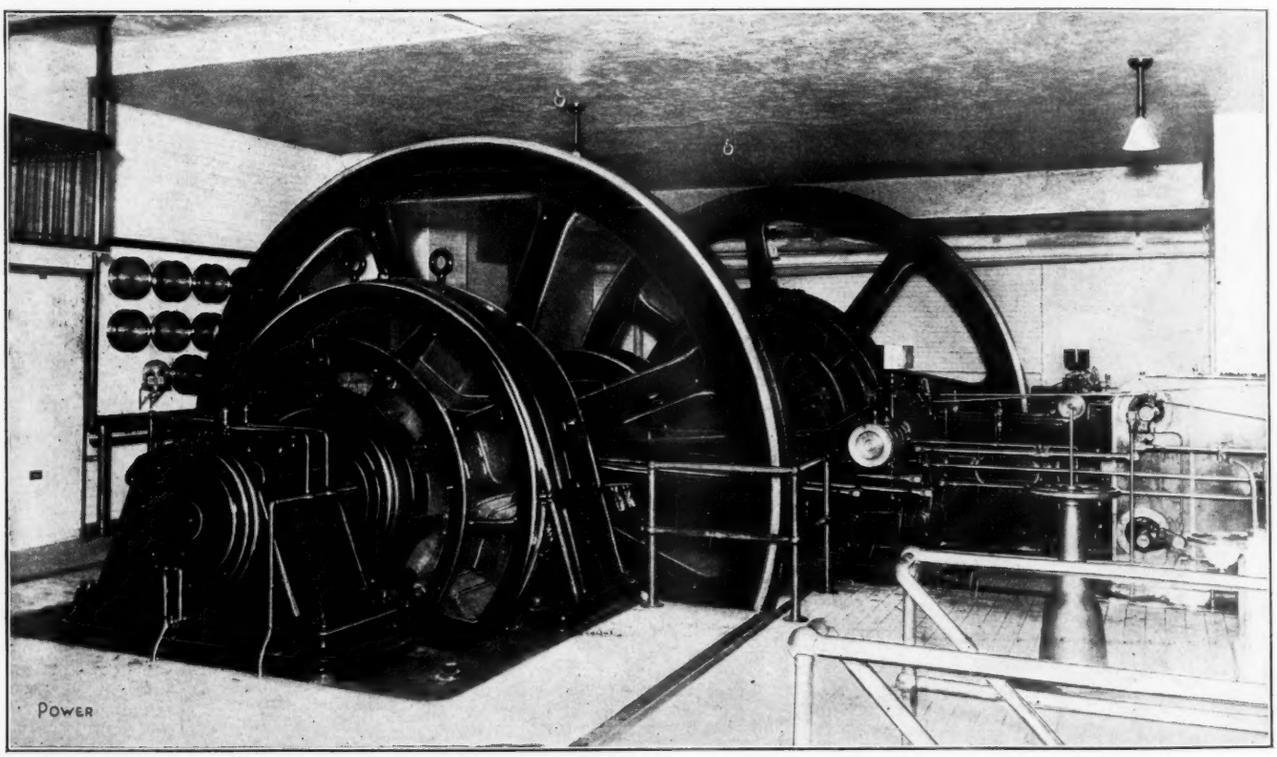

Fig. 4. Generator End of Two of the Larger Units

On the upper level of the pump room are located two Blackburn-Smith feed-water filters; one Reilly multicoil feed-water heater; one Worthington feed-water meter; eight heaters for the hot-water service of the plumbing system; the grease-extractor tank for the 12-in. exhaust line supplying steam to the hot-water heaters and the tempering coils; two air compressors for the automatic heat control; two steam-driven circulating pumps for the plumbing system; two electrically driven air compressors for the pneumatic message system; and several ventilating fans, as well as the engineer's office, which is at a higher level than the engine room.

Engine Room

The engine room contains, besides the electric-generating plant and the switchboard, a 20-ton refrigerating machine of the compression type. The electric-generating plant is made up of four direct-connected units, of which two are of 500 kw., one of 300 kw. and one of 200 kw. capacity. The engines are of the Rice & Sargent tandem

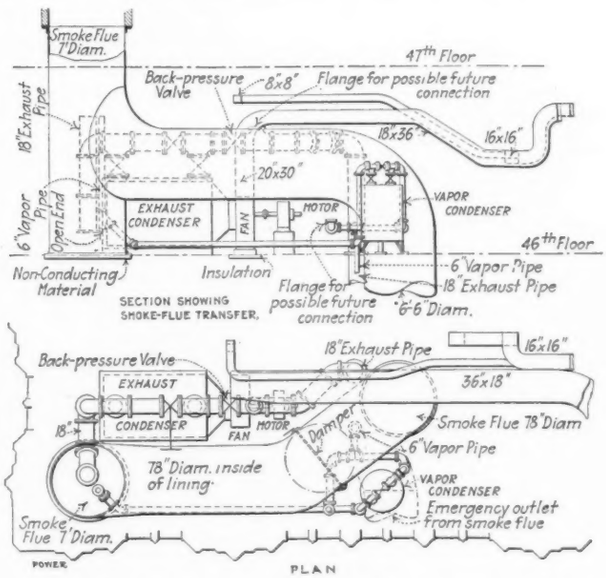

Fig. 5. Condensing the Steam from the Free Exhaust

compound type, and run at 100 r.p.m. The dynamos, as well as the balancer sets, of which there are three, are General Electric.

Directly opposite the switchboard and about on a level with the chief engineer's office is an observation gallery, inclosed in glass, which overlooks the entire engine room. The engine room is finished in white and tiled on both walls and floor, which finish, together with the copper trimmings on the switchboard and the polished-metal surfaces on the machinery, presents an attractive appearance. No pipe work or ducts are visible in the engine room, all being concealed in the suspended ceiling over this room and in the pipe cellar underneath. A clear head room of 13 ft. exists practically throughout.

Piping

Both the power main and the feed main are run on the loop principle. The feed main, which is 5 in. in diameter, is made of brass pipe, so valved that the boilers can be fed in either or both directions of the circuit, making it possible in the event of a break in this line to shut off any section for repairs. In addition to this, an auxiliary cold-water feed line is provided through which the boilers can be filled and washed when desired, as well as fed through the injectors should the regular feed line or feed pumps be out of commission. All the feed piping is covered with nonconducting material except the individual branches connecting with the boilers, which are made up of polished pipe and fittings.

The main power line is arranged on the same principle, with valves placed in the run at intervals to permit cutting out any desired section in case of repairs. In addition to the hand valves each branch from the boilers connecting with the main power line has also been provided with a triple-duty emergency stop and check valve. All branches leading from this main have in no case less than two valves. The portion of the power main within the engine-room section is carried through the pipe spaces beneath the engine-room floor, where connections are taken off to two steam-distributing drums through which the engines are supplied with steam. Each of these drums is 33 in. in diameter and 15 ft. long, built of openhearth steel with triple-riveted butt-strapped seams and anchored to concrete foundations. All valves on the connections to and from the drums, as well as the valves on the exhaust pipes, which are also located in the pipe cellar, are provided with floor stands for operation from the engine-room floor.

All high-pressure steam pipes 5 in. in diameter and over are made up of standard full-weight steel pipe with Van Stone flanged ends and heavy rolled-steel flanges and fittings of extra-heavy gun iron. All smaller high-pressure steam pipes are made up of extra-strong wrought-iron pipe with heavy cast-iron fittings. All large exhaust pipes are also made up of steel pipe with Van Stone flanged ends, but the flanges on these pipes are of standard weight, rolled weldless steel and the fittings are of cast iron. Bent pipes are used wherever possible to minimize joints and fittings and so as to afford ample provision for expansion and contraction without the use of expansion joints.

Drips from the muffler tank, grease-extractor tank and the exhaust piping in general which contain oil are lead to and collected in the low-pressure drip tank, from which they are pumped into the sewer. All high-pressure drips and other drips which do not contain oil are discharged into the receiving tank and utilized for boiler feed.

All piping, as well as the steam-distributing drums, tanks and other hot appurtenances are covered with mag-

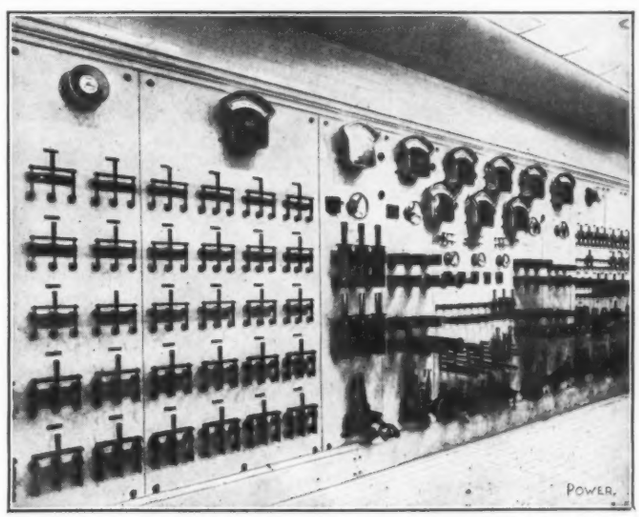

Fig. 6. Main Switchboard in Engine Room

nesia. The covering on the distributing drums, the power piping and the exhaust piping is of double thickness.

Electrical Installation

The number and capacity of the generators was given in a previous paragraph. The building is wired on the three-wire, 125-250-volt system, and two-wire generators

with balancer sets are installed. The total installed load in lamps is approximately 400 to 500 kw., and the total installed load in power is approximately 1400 kw., including the electric elevators.

Perhaps the most interesting thing about the wiring is the vertical length of some of the feeders supplying the upper floors. The longest feeder runs from the switchboard to a panel at the fifty-seventh floor, a total distance of 1000 ft., having a vertical rise of 740 ft. The strain on the vertical section of these feeders is relieved by means of clamps located about 40 ft. apart. The total number of outlets installed in the building is approximately 12,000, and the sizes of lamps vary from 25 to 60 watts.

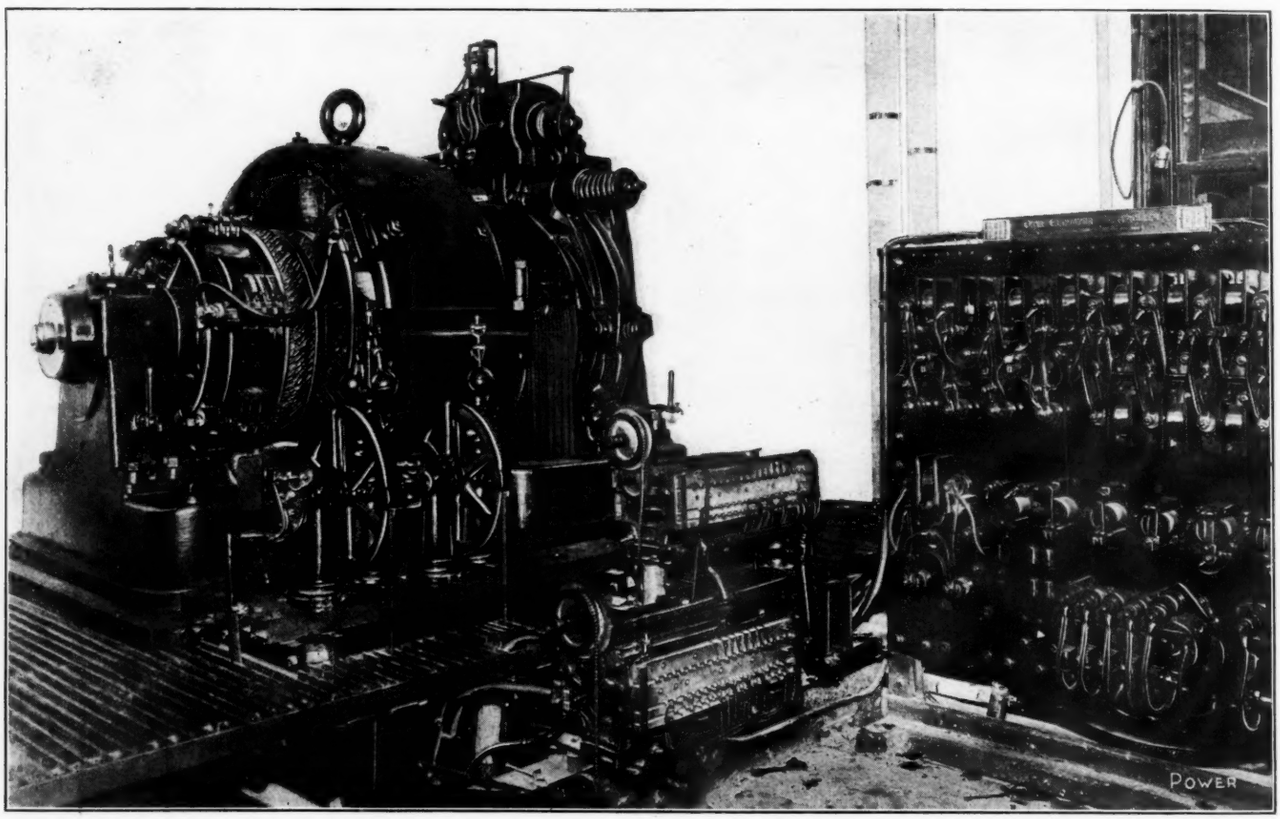

FIG. 7. ONE OF THE TRACTION ELEVATOR MOTORS AND THE CONTROL EQUIPMENT

ELEVATOR EQUIPMENT

There is a total of 28 elevators installed in the building, and one sidewalk lift. The main group consists of 24 elevators, two of which run from the ground to the fifty-first floor; two to the forty-sixth floor and two to the forty-first floor. Four elevators run from the ground to the twelfth floor, and the 14 remaining elevators in the main group run from the basement to the twenty-seventh floor. Two additional elevators, at the rear of the building, serve for freight and employees, as well as for the occupants of the building, these two elevators running from the basement to the twenty-eighth floor. In addition, a shuttle elevator is provided to run to the observation gallery from the fifty-first to the fifty-fourth floor. An elevator is also provided to run from the bank at the second floor to the bank vaults in the basement. The two cars running from the ground to the fifty-first floor have a rise of 680 ft., and these elevators are the highest rise elevators in the world. While it is true that elevator service is provided in the Eiffel Tower, to a height of nearly 1000 ft., it is necessary to use three elevators to reach the top, the highest rise of a single elevator being approximately 450 ft.

The express elevators in the Woolworth Building run at a speed of 700 ft. per min., and are capable of lifting 3000 lb. at that speed. All of the elevators (with the exception of the shuttle and bank elevators) are of the Otis gearless electric-traction type.

In this brief description mention can be made of only some of the more important safety devices which have been provided. These are the under car safety operated by a governor placed overhead, oil buffers placed under each car, a retarding and latching device at the top of each hatchway, limit switches at the bottom and top of travel, a speed governor and potential switches operated by a governor, a switch attached to the safety plank on the under car safety, and an emergency wheel and safety switch inside of the car itself. In addition to this the traction type of elevator has the great inherent safety feature, due to the fact that if either car or counterweight overtravels, the tractive force is lost, owing to the weight of the car or counterweight being removed from the hoisting cables. Furthermore, there are a great number of electrical safety features, which form a part of the controlling equipment which safeguard the operation of the cars. For example, if the current fails for any reason whatever, a switch is opened and the brake instantly applied. Bypass resistance is also cut into the armature circuit under certain conditions which also tends to bring the car to rest.

In addition to all of the safety devices just mentioned, air cushions have been provided for all of the elevators in the building. They consist of a heavy steel structure, inclosing each elevator hatchway separately, with reinforced concrete placed between the I-beams. In addition the inner side of the shaft is lined with heavy sheet metal. As the car approaches the bottom of the travel and enters the zone of the air cushions, the air pressure underneath the car is increased, and this will be slightly noticed when riding in the car. Of course, the theory is that if all the other safety devices should fail and the car fall, the air would be so rapidly compressed, it would not have time to escape through the automatic valves or the clearance space around the car, and the speed of the car would be retarded.

An elevator dispatcher's system has been devised which will be used in the building for the first time. Briefly, the system consists of a dispatcher's station, located on the mezzanine floor, just above but in view of the main group of elevators on the ground floor, and the sole duty of the dispatcher is to start the cars and to make them conform to a given schedule as nearly as possible. For this purpose the station is provided with a lamp annunciator, which shows instantaneously the position of each car, and a telephone switchboard which enables him to communicate with each of the operators, and also a push button which rings a bell or buzzer in the car.

Heating

The entire building is heated by direct radiation, with steam at low pressure, circulating through a two-pipe system, of which the return lines are under a slight vacuum, commonly known as a return-line vacuum system. Approximately 104,000 sq.ft. of radiating surface is installed, which surface is divided into 2990 units. The radiators are of the American Radiator Co.'s manufacture and are equipped with Dunham valves.

Exhaust steam from the electric-generating plant, pumps and other steam-driven appurtenances is utilized for heating and supplemented with live steam reduced to proper pressure when necessary. The main exhaust line leading to the heating system is 22 in. in diameter up to the point where the branch is taken off for connection with the feed-water heater. At this point the exhaust main is reduced to 20 in. diameter, which size is carried up to the pipe gallery between the twenty-sixth and twenty-seventh stories, where an 18-in. branch is taken off. This branch or main is run around the pipe gallery and connected with risers feeding downward to all the radiators on the lower floors, and with all risers feeding upward to the radiators on the twenty-seventh, twenty-eighth and twenty-ninth floors. The vertical line above this pipe gallery is reduced to 18 in. in diameter and run up to a second pipe gallery located between the forty-first and forty-second stories, where a 10-in. branch is taken off, supplying risers feeding downward to the thirtieth story and upward to the top of the building.

The return lines corresponding to the distributing system in the upper pipe gallery are connected into two mains, one run in the upper and the other in the lower pipe gallery, from which levels they are run down to the sub-basement. The return lines corresponding to the risers for the lower distributing system are all run down from the twenty-ninth floor to the sub-basement, where they are connected into one main return. This main and the mains from the upper stories are all connected with the vacuum return pumps after being passed through dirt catchers.

Automatic temperature control is provided for all radiators in the public rooms in the basement and the banking rooms on the second and third floors. All other radiators are controlled by hand.

Ventilating Apparatus

A total of approximately 170,000 cu.ft. of fresh air per minute is supplied by mechanical means to the sub-basement, basement and the banking rooms on the second and third floors, and approximately 182,000 cu.ft. of air per minute is exhausted. In addition to this about 29,000 cu.ft. per min. is exhausted from kitchen hoods, about 28,000 cu.ft. per min. from toilets in the upper stories and about 8000 cu.ft. per min. from the room on the forty-sixth floor in which the condenser tank for the free exhaust is located.

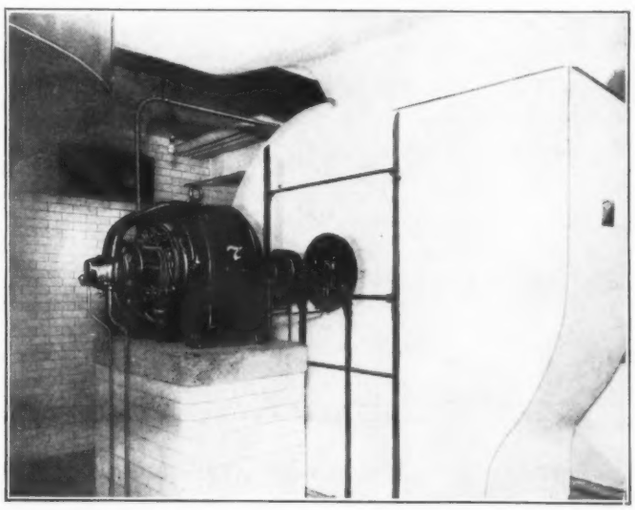

Fig. 8. Typical Fan and Motor Installation for Ventilation

All the air-supply fans, seven in number, and the exhaust fans serving the engine room, the boiler room, the banking-room space and the kitchens (six in all), are Massachusetts centrifugal fans, with the exception of two, which are of the Howard & Morse disk type. The fans are driven by direct-connected slow-speed C. & C. motors provided with field-control regulating devices allowing a speed variation ranging from one-half to full speed.

The air supply for the machinery spaces is delivered at external temperature after being passed through cheesecloth filters, but that for the banking rooms, restaurants, swimming pool and other public rooms is passed through air washers and tempering coils where the required temperature conditions are automatically maintained.

The architect of the building was Cass Gilbert, with L. E. Eden acting as advisory engineer; Charles E. Knox was the consulting electrical engineer; the steam power, heating and ventilating equipment was installed by the Thompson-Starrett Co. under the direction and from plans and specifications prepared by Messrs. Nygren, Tenney & Ohmes, consulting engineers. For the data contained in the article the author is largely indebted to Messrs. Nygren and Knox.

A Unique Temporary Flue

By Charles H. Bromley

SYNOPSIS—Four more large boilers are installed back to back with eight already in operation. A larger flue is needed but structural conditions do not allow of putting in an overhead temporary flue while the larger permanent one is erected. A solution of the problem is found by using the alley in the cellar, the alley being formed by the building wall and the backs of the soot pits and leading directly to the chimney.

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When plants, particularly office and public-building plants, are extensively remodeled or large additions are made to them, the problem of maintaining uninterrupted service while the changes or additions are made often becomes seemingly impossible of solution. In the plant in question this problem was extraordinary. One of the most interesting features of the work carried on was the making of a flue to serve temporarily while a new and larger flue was installed. The temporary flue could not

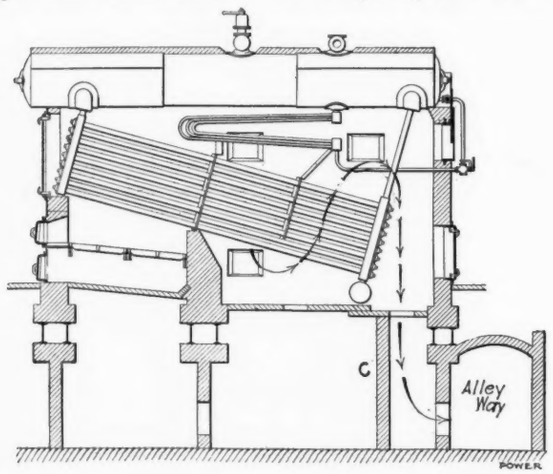


Fig. 1. Sectional Elevation Showing Soot Pits and Passage of Gases

be erected alongside or above the old one because of lack of room.

The boilers are of the B. & W. type, 250 hp., two boilers to a setting. The settings were provided with soot pits, as shown in Fig. 1, a door covering the opening being lifted so that soot from the back chamber may be dropped into the pits. These soot pits are, of course, in the cellar immediately below the boiler-room floor level. The four new boilers are of the three-drum type, 550 hp. each, one boiler to a setting. They were placed with their back chambers facing the back chambers of the eight 250-hp. boilers, with an alleyway about 5 ft. wide between. Obviously the combined boiler capacity required a much larger flue than the one serving the eight 250-hp. boilers.

As stated before, lack of room prevented building a temporary flue adjacent to the old one so that the latter could be torn out and a new and larger one installed. These soot pits *AAAA*, Fig. 2, and the building wall *B* offered a means of making a temporary flue, as the alleyway, about 4½ ft. wide and 6½ ft. high, led directly to the clean-out door of the stack, as shown. Each soot pit had a door at both ends to allow of taking out the soot and to admit air to the steam-jet blowers which produce the draft. By making the upper opening into the pit of the same area as the area of the uptake, building solid walls *C* to the right of and in line with the opening,

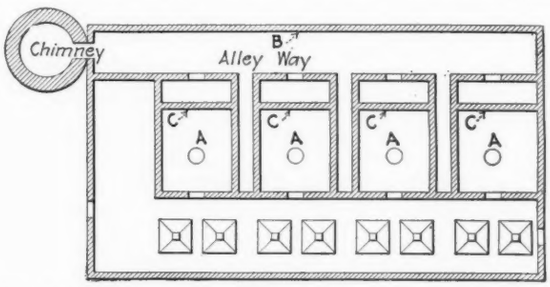


Fig. 2. Plan of Soot Pits, Ash Pits and Alleyway

also removing the clean-out door of the chimney, and closing the "back dampers," a direct and inclosed passage was made for the gases. The doorways at each end of the alleyway were, of course, closed with masonry. It was important that a tile brick or door be placed in the walls *C* to provide means for cleaning soot from the space within. As the wall is only a temporary one, it is cheapest to use a tile brick, such as is used between beams where a concrete floor is to be laid. It should be noted that the changes in no way interfered with the action of the steam-jet blowers because the front doors of the soot pits allow air to enter to supply all that necessary to produce the draft.

The only real disadvantage of such a flue is that, being on a level with the floor of the chimney, the soot cannot drop away from the point at which the gases enter the chimney. This will cause the opening into the chimney to be obstructed with soot more quickly than with the usual arrangement. It is, of course, understood that be-

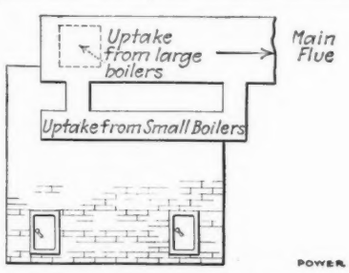


Fig. 3. Connections to Flue

fore any work was begun on the temporary flue, the soot was removed from the boilers, pits and chimney base.

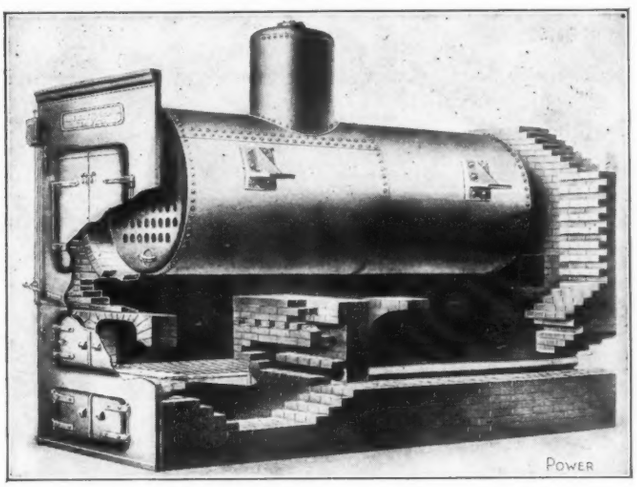
After the intake opening in the chimney had been closed off by sealing the old flue near the stack, the work of removing the old flue was begun. The new, permanent flue arrangement was made as shown in Fig. 3, which illustrates the back of a setting for two of the 250-hp. boilers.

No damper was installed in the temporary flue. This job was done at the plant of the Prudential Insurance Co., Newark, N. J.

Sullivan Smokeless Furnace

This furnace has been designed to prevent the formation of smoke and by so doing the combustion of bituminous fuel is practically complete and the boiler shell and tubes are less liable to become coated with soot.

When installing this equipment no change of furnace construction is necessary, and it can be installed under a boiler in 48 hours. The equipment is illustrated here-



CONSTRUCTION OF SULLIVAN SMOKELESS FURNACE

with, and is built by The Sullivan Smokeless Furnace Equipment Co., 90 West St., New York City.

When installed a special bridge-wall is built of firebrick and a special prepared mortar is used. The bridge-wall is made as shown. Air enters through the tube, in the case illustrated, from the rear end of the boiler setting, but this tube can come out through the side of the setting, or wherever convenient. As the escaping gases go to the boiler uptake a partial vacuum is created in the furnace which pulls in air through the air duct and through the three passes in the bridge-wall, the quantity of air entering the furnace varying with the amount of vacuum created by the chimney draft, which is greatest when fresh fuel is introduced or when the grates are covered with ash.

In the upper pass outlet holes are provided on the fire side of the bridge-wall. They are so proportioned that the same volume of air escapes through each one to the furnace, i.e., the outlet hole on the right-hand side of the upper pass, where the air pressure is the greatest, is made smallest, each succeeding hole being made a little larger than the preceding one. By this arrangement the air is evenly distributed above the burning fuel. Before the air reaches the furnace it is heated both in the air tube and in the bridge-wall passes. This heated air unites with and balances the variable air supply through the grate bars. No other agency is employed for introducing air to the furnace.

In combination with the heated air, steam is introduced through the front of the furnace just after a fresh supply of fuel has been put on the fire. The steam enters the furnace above the fire through a curved metal retort. The steam escapes through small orifices at the front of the steam retort, facing the bridge-wall, in a fine spray. The retort is embedded in the front wall above the arches, as shown, with but a width of 1⅜ in. exposed to the fire. As the face does not come flush with the firebricks there is little chance of the steam holes becoming clogged.

Steam is supplied to the retort through a ½- or ¾-in. pipe connected to the steam outlet of the boiler. A special balance valve is operated by an automatic time regulator, so mounted that steam is turned into the furnace whenever the firing doors are opened. As soon as the doors are shut after firing, the valve starts to slowly close and continues to gradually throttle the steam, coincident with the reduction of excessive hydrocrabons rising from the newly fired fuel, until the steam is finally cut off. The period for closing the valve can be regulated by adjusting the time regulator. Back of the curved bridge-wall an arch is made, as shown, to assist in keeping the flames close to the boiler shell.

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A Curious Smoke-Stack

The stack shown is installed at the plant of the Keokuk Water Co., Keokuk, Iowa, which furnishes the water supply to the town. Advantage has been taken of the Mississippi River bluff, to obtain a strong draft at comparatively low construction cost. The plant is at the bottom of a 150-ft. bluff, the stack leading off nearly level

A MANY-ANGLED SMOKE-STACK

until it reaches the bluff, then up a sharp angle for some distance, and then at a greatly decreased angle with the horizontal until at a distance of 300 ft. it leads into an ordinary vertical stack.

Boiler Tests on Shipboard

By H. S. Knowlton

The difference in operating conditions in steam plants ashore and afloat is well illustrated by the problems arising in each case when it is desired to carry out a service test of the apparatus. Engineers, whose practice is confined to land installations, frequently do not realize the expedients which are necessary to obtain accurate results aboard ship, or the difficulties encountered in trying to follow well known standard land methods of procedure. It is, nevertheless, possible to obtain thoroughly reliable data without following in detail the practice of engineers on land, and an illustration is afforded by a test of the boilers of a turbine-driven ship.

In this typical case the vessel was provided with 12 single-ended Scotch marine boilers placed in two rows, half on each side of a transverse bulkhead and supplied with coal from forward and aft bunkers served by buckets traveling on overhead runways. Each boiler had three furnaces and the capacity of each bucket was 500 lb. In the carrying out of the tests it was not feasible to either clean out all the fires at the start or to draw the fires, on account of the limited space in the boiler rooms and the probable delaying of the vessel. Neither was it possible to weigh all the coal as fired in the buckets or to fire directly from the latter into the furnaces.

Owing to the cramped quarters in the fire room and the rapidity with which the coal had to be passed out, no attempt was made to weigh the fuel during the trial. Each bucket supplied nine furnaces, and in firing, the coal was dumped on the floor in front of the furnaces and fired from this level. The weight of the coal used was determined by counting the number of buckets taken from the bunkers, a man whose sole duty it was to count these being stationed in each compartment of the fire room. Great care was taken to fill the bucket flush with the top, and after the test four buckets were weighed full and empty with the result that the average value agreed to a pound with previous weighing made by the company. Crude as this method appears, it gave a value for the coal agreeing within 1 per cent. with the figure obtained by the chief engineer of the company as the average coal consumption per trip, based on the runs for a whole season. Throughout the test, which lasted seven hours, 223 buckets of fuel were supplied.

The feed water was metered and tests showed that the measurements were accurate within 2 per cent. The usual requirement that feed water be weighed in tanks is impracticable on shipboard. These boilers were supplied with 3000 lb. of water per min. With the boilers placed athwart the ship it was found undesirable to attempt to ascertain the water level by the gage-glasses because of the rolling motion of the ship.

The operating engineers had found that by admitting fresh water for a certain period during each trip the level in the boilers could be made approximately the same at the beginning and end of each run. The total feed-water supply when plotted against time showed practically a straight line. The steam used by the auxiliaries was determined by calculation of the amount discharged through an orifice of fixed size.

The methods employed gave ultimate errors in the steam and fuel consumption not exceeding 3.5 per cent., the feed-water requirements being known within about 1 per cent. In this test an error in the auxiliary steam consumption of 10 per cent. could not affect the turbine steam consumption by over 1.2 per cent., and an error in the feed-water consumption would not affect the turbine steam consumption by more than 1 per cent.

The equivalent evaporation was affected by five factors: The boiler pressure, quality of the steam, temperature of the feed water, the feed-water rate and the coal rate. Any errors likely to occur in the first three items were seen to be negligible in comparison with errors in the last two, so that the error introduced in the equivalent evaporation per pound of coal did not exceed 2.5 per cent. In this case the departure from the usual methods did not interfere to any appreciable degree with the usefulness of the test, and the point may well be emphasized that it is often possible to do thoroughly good commercial work under conditions unfavorable to the accuracy of the engineering laboratory.

❋

Improved Regan Stoking Grate

A furnace grate and mechanical stoking device that eliminates the necessity of using a slice bar and the necessary opening of the furnace doors while performing the work of slicing the fires is attracting the attention of engineers. This device, Fig. 1, permits of carrying a

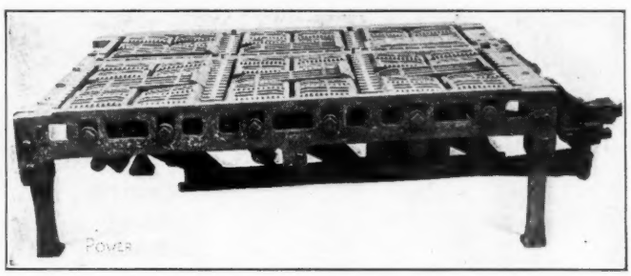


Fig. 1. View of Grates at Rest

uniform thickness of fuel without opening the furnace doors for slicing and leveling the fires, and they can be practically run without cleaning because the action of the stoker keeps the fuel in a porous condition and breaks up the clinkers as they begin to form. This results in a free supply of air through the fuel bed.

The stoker consists of a series of lifting fire bars extending the length of the grate, each series spaced about 18 in. apart across the middle of the grate, Fig. 2. There are also stationary grates running across the furnace separating the stoking and chopper grates from the next series of grates. This feature is shown in

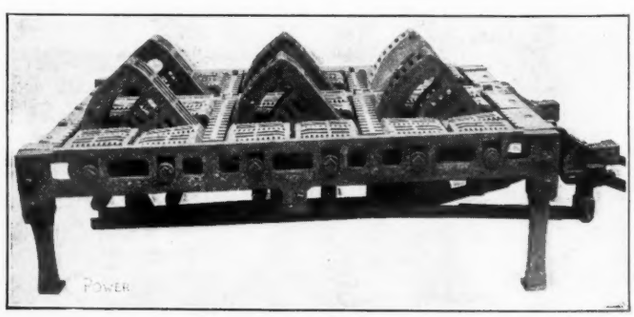


Fig. 2. As Barring Grates Look in Action

Figs. 2 and 3. The stationary bars are made with a concave surface on the sides and the stoking and chopping members are made with the convex outer ends of the same radius curve. The inner end of each chopping grate is made at a right angle to the face and the two opposing grates are so spaced that, when in their rest position, the fuel does not fall between them into the ashpit. The concave and convex surfaces of the stationary grates and the outer ends of the chopping grates are also brought so close together that sifting of fuel does not occur.

Levers for actuating the stoking grates are attached to the shaker which operates the chopper grates, but their movement is independent of the choppers, although the shaker grates may be operated in connection with them if desired. When in service the stoking device operates about as follows: All grates occupy the position shown in

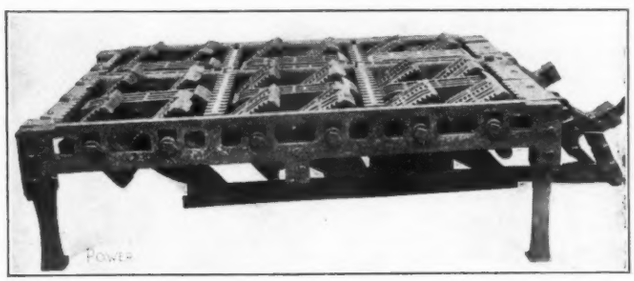


FIG. 3. CHOPPER GRATES IN ACTION

Fig. 1, forming a flat surface. The fuel is hand fired in the usual manner, and then the old method of leveling and baring the fires gives way to the new. When it becomes necessary to bar the fires, as in the old method, the lever operating the stoking grates raises the end nearest the front of the furnace above the grate level. This movement lifts the burning fuel and breaks up the coal, at the same time throwing it toward the bridgewall. In Fig. 2, the stoking grates are shown operating in an opposite direction, which throws the fuel toward the front of the grate. Grates with either action may be obtained.

When the fire requires cleaning the chopper grates, Fig. 3, are operated, shaking the ash and small clinker into the ashpit. All grate sections are made extremely heavy, as shown in the illustrations.

The stoking grate is made by the Regan Grate Bar Co., 209 North Front St., Philadelphia, Penn.

An Unusual Water-Power Station

In connection with the construction work on the White Salmon River, Washington, 75 miles east of Portland, Ore., of the 20,000-hp., hydroelectric development, it was found necessary, by the Stone & Webster Engineering Corporation, to establish a temporary hydraulic plant for furnishing power for carrying on the work incident to the building of the large plant.

A power flume, 9 ft. 3 in. wide, built of wood, diverts water from the stream right through the new 125-ft. dam now in process of construction, carrying it to a point a few hundred feet below the dam where the small wooden power house has been established, the turbine operating under a 13-ft. head of water. The prime mover is a 54-in. S. Morgan Smith Co. turbine, capable of delivering a maximum of 300 hp. at this head.

This turbine is directly connected to a 150-kw., 440-volt generator. The electric power is used for various purposes on the immediate work, including quarrying on top of the hill, 400 ft. above the dam, operating concrete mixers, lighting, drilling, etc. It is also used at a point more than a mile down the river where the power house is being built, to which point it is transmitted at 6600 volts.

The depth of water in the flume is kept at 6 ft. by an ingenious arrangement of gates, such that when the water falls below 6 ft. a bypass is closed and the flow is built up; when the water tends to exceed 6 ft. the bypass is opened wide and the excess water turned into the bed of the stream between the big dam and the temporary power house.

This development, which is to be operated by the Northwestern Electric Co. of Portland, will have a head of 175 ft. and an impounded volume of 40,000,000 cu.ft. of water (1,250,000 tons). This water is gathered from a drainage area of 350 sq.mi. and is held back by a concrete dam of the solid gravity type, 470 ft. long with a 250-ft. spillway, measuring 125 ft. in height. Water will be carried from the dam to the power house by a wood-stave pipe 5100 ft. long and 13 ft. 6 in. in diameter, emptying into a concrete forebay. From this point two pressure pipes 700 ft. long and 9 ft. in diameter will give an operating head of 175 ft. The purpose of the development is for lighting and power in Portland and vicinity.

Deterioration of Steel Stacks

Of eleven companies using steel stacks, three have noticed no deterioration, says the Prime Movers Committee of the N. E. L. A. With one of these companies the stacks are lined, with another company unlined, and the third did not say whether the stacks are lined or not. All the other companies report serious corrosion of the steel. They all have unlined stacks except one company, which in lining the stack had left an air space between the brick and the metal, and in this case the corrosion was so serious in a short time that the lining was taken out, the metal scraped, and the lining rebuilt with grouting between the brick and the steel.

All of the unlined stacks reported on are apparently corroding very seriously, and almost entirely on the inside, the corrosion appearing to be worse on the upper rings. This is attributed to the moisture in the flue gases, which is condensed against the cold metal of the stack and, carrying with it a trace of sulphurous acid from the fuel, attacks the metal. As a stack is never scraped or painted on the inside, regardless of the amount of care which may be bestowed upon it on the outside, the corrosion goes on rapidly and uninterrupted, and stacks which are well cared for and frequently painted on the outside, presenting a good external appearance, are in a few years found to be in a dangerous condition, due to internal corrosion.

A simple and effective remedy for this condition is to line the stacks from bottom to top, taking care that the job is thoroughly grouted as it goes up, so that every part of the metal will be protected with cement. Stacks of this construction at the Harrison St. station of the Commonwealth Edison Co. have been standing for 20 years, much of the time in service. They have been painted every two years and are now apparently in as good condition as when first built.

ELECTRICAL DEPARTMENT

Hydro-Electric Systems*

Waterwheels

A rapid evolution has taken place in the design of waterwheels, the most marked being the increased application of single-runner, vertical-shaft turbines to low heads, where previously multi-runner turbines of either the horizontal or vertical type were used.

In low-head installations the single-runner turbine has a number of advantages over the multiple-runner. Only one gate-operating mechanism is required and this is located above the head cover of the turbine and is thus accessible at all times for inspection, while repairs can readily be made without dismantling the wheel. A better design of the draft tube is also made possible with a single-runner unit, and it is possible to mold in the concrete a spiral turbine casing similar in design to the cast-iron spiral casings used with high-head turbines.

Tests of two 6000-hp. vertical single-runner turbines, having concrete spiral casings and ideal draft tubes recently showed an average maximum efficiency of 93.7 per cent.

Generators

Generators should have a rating corresponding to the point of maximum efficiency of the waterwheel, as the efficiency of the latter, especially for low heads, falls off rapidly above and below this point. It is, therefore, desirable to operate the wheels near their maximum output, leaving only a small margin for regulating purposes, and the generator should preferably be given a maximum or continuous rating corresponding with the waterwheel.

While both 60- and 25-cycle generators are being installed as conditions determine, the increase in the size of the individual units has made it desirable to wind a large number of these for 11,000 and 13,000 volts. Very satisfactory results are being obtained by grading the insulation, and the slight corona effects noticeable on some coils at high altitudes is now readily taken care of by proper design of the insulation.

A general agreement has been reached to consider the maximum runaway speeds of waterwheel-driven units at 100 per cent. increase.

Three-phase generators should always have their armature windings connected in star. Whether the generator neutral should be grounded or not depends on conditions.

Exciters

The capacity of the exciters should be sufficient to excite all the synchronous apparatus in the station when these machines are operating at their maximum load and at the true operating power factor.

A 125-volt excitation pressure has been considered standard for moderate-size installations, while for larger plants a 250-volt exciter system will generally be found more economical. Almost all exciters are now of the direct-connected type. They may be driven either by the main generators, by separate waterwheels or by motors. The system most favored from an operating viewpoint is one in which excitation is obtained from a common source consisting of as few exciters as possible. Three units are generally provided, two for normal operation and the third held in reserve. A difference of opinion exists as to whether the two exciters used for normal operation should be waterwheel driven and the reserve unit motor driven, or *vice versa*. It seems, however, preferable to have the former motor driven; the waterwheel-driven exciters should then be used only when starting up or as a reserve.

In some of the latest hydro-electric developments a new system of excitation is being used, in that one small motor-driven exciter set is provided for each generator unit. The exciter has a capacity corresponding to its generator and the terminals are connected directly to the generator field. The motors of the various exciter sets are fed from one or two low-voltage generators driven by independent waterwheels, but in addition, the connections are so arranged that if necessary the motors may be connected to the main busbar through transformers, two separate sources thus being provided. With this arrangement the objection to motor-driven exciters on the ground that they are likely to fall out of step when a short-circuit occurs on the system, has no bearing.

Transformers

The number and size of the transformers and whether they should be of single- or three-phase type, depends entirely on the conditions to be met. With moderate voltage it has been the general practice to install one transformer bank for each generator. With a large number of units it was more advantageous to install three-phase transformers, while in plants consisting of one or two generating units where the cost of a spare three-phase transformer was not warranted, it was preferable to install single-phase units.

With present modern high-voltage systems where it is undesirable to parallel the transmission lines on the high-tension side, it has become general practice to install the transformers in groups, each having a capacity corresponding to a line. The transformers may be connected either in delta or in Y, but it is now generally conceded that the isolated delta connection is preferred, because of increased reliability. Under normal operation the voltage stress is the same whether the isolated delta or the grounded Y-connection is used, but in case of a ground on one line wire, the isolated delta system will be exposed to a higher voltage above ground than would be the case with the grounded Y-system. The disadvantage of the grounded Y-system, however, is that any ground of the line wires will cause a short-circuit and thus a shutdown, which is not the case with the delta.

The transformers should always be provided with taps.

*Excerpts from the report of the committee on the "Operation of Water Power Systems" of the National Electric Light Association.

In many instances it is desirable to begin the operation of the system at half the ultimate voltage and to accomplish this the transformers are provided with 50 per cent. taps in the high-voltage winding. It is also customary to provide the high-voltage windings with four 2½ per cent. taps below the normal operating voltage so that these can be used in compensating for the line drop as the load increases.

Power-Limiting Reactances

Increase in the size of modern generating units and the concentration of enormous power in single generating stations or systems have made it necessary not only to increase the inherent reactance of the apparatus but also to provide artificial reactances for limiting the amount of current that may flow from any part of the system into a short-circuit in apparatus or connections. By so limiting the abnormal flow of current into a short-circuit the generating system, as a whole, is relieved from possible disastrous effects.

Power-limiting reactances may be divided into three classes—generator, busbar sectionalizing and feeder reactances. The first is not used to any great extent in connection with waterwheel-driven generators, as these have, as a rule, sufficiently high inherent reactance. Busbar sectionalizing reactances are, however, becoming generally used in large stations. When a busbar becomes so large that it becomes desirable to divide it into several sections, reactances may be placed between the sections permitting any section to draw only part of its load from the adjacent sections and thus limiting the short-circuit current of one section.

Regulators and Synchronous Condensers

Regulation of large high-voltage systems involves difficulties not encountered in low-voltage work. In the latter case the energy loss is generally the limiting factor and the regulation can often be improved by installing larger conductors, which at the same time reduce the line loss. With high-voltage systems the gain from doing so is very slight, and other means must be employed for keeping the regulation within commercial limits. The effect of the inductance and capacity of the line causes the voltage to vary within very wide limits from full to no load. At no load the large capacity current causes a rise of voltage from the generating station to the receiving end, while at full load the lagging inductive current taken by the load, in general, more than offsets the effect of the capacity current and causes a drop of voltage from the generating station to the receiving end. It is evident then that by installing a synchronous condenser at the receiving end, and taking advantage of the characteristics of this machine, the receiving voltage can be kept constant by adjusting the synchronous condenser field and causing the condenser to draw a lagging current from the line at no load and a leading current at full load. The generating voltage should preferably be kept constant by means of automatic T. A. regulators. Automatic regulation of the condenser field current can also readily be accomplished by means of a T. A. regulator.

As the excitation must at times be practically zero, a special exciter arrangement must be employed to provide for the limiting voltage range of the regulator. This is accomplished by exciting the condenser from a 250-volt exciter, whose fields in turn are separately excited from a 125-volt source, consisting of two small exciters which are running opposed in series. One of these exciters is designed for 125 volts and the other for 250 volts, the regulator being placed across the 250-volt exciter. In this manner the range of the regulator is from 125 to 250 volts, never reaching zero, while the excitation of the condenser is from zero to 250 volts.

Systems of Connections

The generators should preferably be in parallel on a common low-tension busbar the generator switches being nonautomatic, or if automatic protection is desirable the switches should be provided with definite time-limit relays, set very high. Reverse-power relays are also occasionally installed, but are generally arranged to ring an alarm gong in case of reversal of the power, and will not trip out the switch.

It is customary to provide nonautomatic oil switches in the outgoing and incoming lines to be used in case of sectionalizing and in addition nonautomatic tie switches should also be provided between the lines, or if more than two lines are present it may be advisable to provide high-tension transfer busbars. Sectionalizing switches of the knife-switch type should be installed at certain intervals on the towers along the line, so that the circuits may be sectionalized in two or more sections to facilitate testing and for isolating line troubles.

With this system of connections considerable responsibility is placed on the operators, as the relays of the transformer switches must be set at from 100 to 150 per cent. overload, or above the safe continuous operation of the transformers. Assume, for example, a system with two parallel lines connected to two transformer groups on the unit principle. A trouble in one of the lines will then cause it to be disconnected together with the transformers through which it is fed. This then throws all the load over to the remaining line, which, with its transformers, will be overloaded 100 per cent., and in order that this line shall not be disconnected at this increase in the load, the relays must be set for more than 100 per cent. overload. Transformers can, however, carry 100 per cent. overload for five or ten minutes, which should give the operator sufficient time to sectionalize the defective line and connect the transformers in parallel to feed the remaining line.

Lightning Arresters

Aluminum-cell electrolytic lightning arresters are now used almost entirely for lightning protection of high-voltage transmission systems. This type has an enormous discharge capacity, and its general characteristics are well known. The arrester, however, is not a universal protector against all kinds of interruptions. For example, while it meets the usual needs in protection against disruptive potentials from lightning, an arrester located in the station cannot protect an insulator out on the line from a lightning flash. Neither is it designed to protect against surges of relatively low potential.

The comparatively recent addition of a charging resistance will insure a material improvement in the operation of the arrester, as well as increased life of cones and electrolyte. The charging current is limited, and its wave form is so modified that, even with such a delicate test as a parallel telephone circuit, it is impossible to

detect any action of the charging on resonant parts of the circuit.

Handling the Load

Most modern systems of any size have a method of operation which corresponds to that of a train dispatcher on steam railroads, and where many different plants are attached to the same network this becomes practically necessary. The directions for operating the different stations and apparatus come from a central source, where the chief operator has before him a diagram of the system and information regarding the capacities of the generators in use and of the magnitudes of the loads at the different places of distribution.

In the larger hydro-electric systems there are usually some plants which have storage, and others which do not, so that a distinction in operating these is well made by having the storage plants do the regulating for the system. The switching operations are determined by the general method of operation.

When a line is to be cut into service, the high-tension switches in both the main and substations should be closed first, then the low-tension transformer switch in the generating station should be closed, energizing the transformers and the line, after which the low-tension transformer switch in the substation is closed and the load picked up. In case it becomes necessary to open a high-tension switch in a loaded line, the circuit should, if possible, first be paralleled with another before opening the switch. If, on the other hand, transformers are to be paralleled on both high- and low-tension sides, the low-tension switch should be closed first, assuming that the low-tension busbar is energized. Similarly, in cutting out the transformer the low-tension switch is opened last.

Voltage on Short-Circuit

A correspondent asks, "Why does an inductor alternator generate no voltage on short-circuit?"

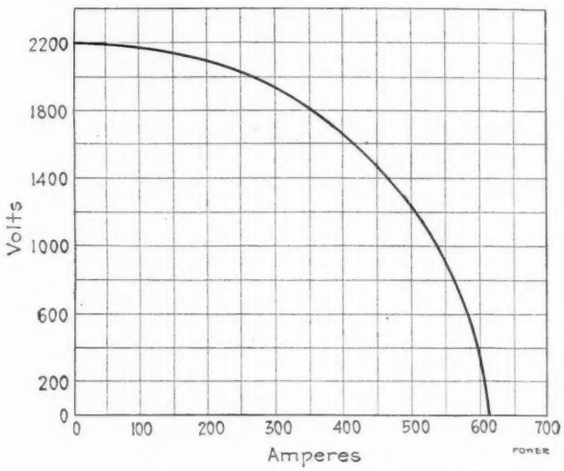
In discussing the cause of the no-voltage condition upon short-circuit, consider the curve which shows the variations of terminal voltage with simultaneous changes of load current, the speed and the resistance in the field circuit remaining constant.

In general, this curve for alternators will be of the approximate form shown, with a gradual slope toward the horizontal axis. The drop in voltage is due to the resistance, self-induction and reactions of the armature. As the load is increased, the I^2R loss is raised together with the e.m.f. of self-induction. The latter is expressed by the formula $E = 2\pi fLI$, where f is the frequency, L the coefficient of self-induction for the armature and I the current. It is evident that as the loads become heavier, the e.m.f. of self-induction is correspondingly increased. This pressure is opposed to the flow of the current and to the voltage producing it; hence as the self-induction increases, the terminal voltage diminishes.

The armature reactions, increasing with the external current, also have a lowering effect upon the machine voltage by opposing and distorting the field flux.

The form of the external characteristic depends upon the design of the machine. For alternators whose armatures contain a large amount of self-induction, the curve will cross the horizontal axis at lower current values than with machines of the same capacity whose armatures do not contain as much self-induction. The armature reactions also have a pronounced effect on the curve.

The zero voltage reading on short-circuit, of the generator in question, is not necessarily due to the fact that the machine is of the inductor type, inasmuch as the general principles governing the operation of these machines are practically the same as for the movable-coil



Variation of Voltage with Current

types. The main distinguishing feature of the inductor class is that both its field and armature coils are stationary, the alternations of field flux being produced by laminated iron projections, or inductors, which are carried on a revolving spider. There are many designs and makes of this type; hence the armature circuits of some will contain more inductance than those of others. In this case, the e.m.f. of self-induction together with the I^2R drop and armature reactions undoubtedly became so great upon short-circuit that the terminal voltage was reduced to zero, but this might have happened under similar conditions with an alternator of the movable-coil type.

Loss of Voltage

Among the "Inquiries of General Interest" in the May 20 issue was one with the heading, "Loss of Voltage." While friction between the brushes and the commutator might account for some loss in voltage yet it would hardly seem possible that all of the drop was on that account. As without load and with all resistance out of the field rheostat the voltage was only 300 volts and as that is 50 volts more than the rated pressure for the machine it would not be surprising if, at full load, the voltage should drop down to normal. Another point which might indicate that the drop was caused both by the reaction in the armature caused by the heavy load and also by the increased resistance of the shunt field, due to its heating when under heavy load, is that the rating of the generator is evidently wrongly given at the beginning of the question. There the load is given as 250 volts and 80 amperes, but the capacity is said to be 33 kw. Could it not be that the operator has made a mistake and the machine is carrying more load than it was designed for?

This would cut down the voltage and would seem to be borne out by the fact that the dynamo gets very warm.

Brooklyn, N. Y. G. H. McKelway.

GAS POWER DEPARTMENT

Heat Balance of a Producer*

By Julian C. Smallwood

The heat of coal consumed by a producer is distributed in four parts: First, the useful heat, appearing as the calorific value of the dry, cool gas; second, the heat carried by the gas as sensible heat and as latent heat of the excess steam; third, the heat lost to good fuel removed with ash; fourth, the heat lost through deposits of tar and soot, absorption or leakage of gases, and radiation from the producer.

The selection of methods of measuring these heat quantities is governed somewhat by the type of producer and the fuel. In any case, it is necessary to measure the coal and ash during a test of sufficient duration, and to provide a proximate analysis of the coal and a chemist's analysis of an average gas sample. The gas usually contains between 10 and 20 per cent. of hydrogen, 1 to 3 per cent. of marsh gas, and a small amount of olefiant gas, in addition to CO_2, CO and N_2.

The calorific values of both coal and gas may be calculated from their analyses.

The volume of gas generated may be figured from the gas analysis with acceptable accuracy in most cases. This calculation depends upon the assumption that all the carbon gasified appears in the gas analysis. It is, therefore, approximate since the condensible hydrocarbons distilled from the coal throw down some carbon in the form of tar, and some disappears as soot. In the case of anthracite gas, or well fixed bituminous, this is almost negligible.

The largest error likely to occur is in the measurement of the coal; hence the conditions at starting and stopping should be noted and made in all respects nearly the same as is possible. Starting and stopping should be timed just after a regular cleaning. The duration of the test should be long enough to reduce the probable error caused by the variation in fuel content of the producer to a small percentage of the total coal fired; this, in general, will not be less than 12 hr. Uniform coal consumption, as well as uniform external conditions, must be maintained as constant as possible and the producer should be run for some hours under the required conditions before starting the test.

The ash and refuse should be collected at regular cleaning intervals and weighed after drying. It is best to secure a sample of the total refuse just before weighing and to determine its moisture and carbon as in the proximate analysis of the coal. It is often awkward to dry all the refuse thoroughly, but, if the percentage of moisture is known, the weight of dry refuse may be readily figured.

Sampling of the coal and ash should be done as for a boiler test. Sampling of the gas should be as described in the article on "The Heat Balance of a Gas Engine," appearing in the Apr. 1 issue. The gas should be collected before entering the scrubber, and after leaving it if it is desired to find the effect of absorption or leakage.

The weight of steam furnished to the suction producer, exclusive of that due to vapor in the air and moisture in the coal, may be found by supplying the vaporizer with water from a calibrated vessel and collecting and weighing the overflow. For a pressure producer, an orifice or nozzle method may be used to meter the steam, or it may be measured by weighing the feed water evaporated by the auxiliary boiler.

The calculations from the test of an anthracite suction-producer plant will first be given, and then the modifications necessary for other types. Tables 1 and 2 give the required test data together with the notation used in the formulas. The data are part of the full observations of a test reported in the *Journal* of the A. S. M. E., December, 1909, for which the ultimate as well as the proximate coal analyses and calorimetric determinations of fuel and gas were made, and the gas metered. The reader may thus compare the results by the approximate formulas to be presented with the more exact results of the report.†

TABLE 1. DATA FROM A SUCTION-GAS PRODUCER TEST AND NOTATION USED IN FORMULAS

Total weight of coal charged, lb.	= 798
Total weight of ash and refuse, lb.	= 85
Total weight of water used in vaporizer, lb.	= 268
Proximate analysis of the coal. Percentage by weight of the coal as fired.	
Moisture	= 2.75
Volatile matter	= 6.00
Fixed carbon	= 78.45
Ash	= 12.8
m, vm, fc = Weights of moisture, volatile matter, and fixed carbon per pound of dry coal, respectively.	
Weight of carbon in 1 lb. of dry refuse, pounds	= 0.388
C_t = Total weight of carbon in 1 lb. of dry coal, lb.	
C_a = Weight of carbon wasted in ash, per lb. dry coal, lb.	
C_g = Weight of carbon gasified, per lb. dry coal, lb.	
c, p = Sums of columns (3) and (5), Table 2, respectively	
V = Volume, standard cu.ft. of dry gas generated per lb. of dry coal	
W_p = Weight of the producer gas per lb. of dry coal, lb.	
W_a = Weight of the air furnished per lb. of dry coal, lb.	
W_s = Weight of steam furnished per lb. of dry coal, from the vaporizer, lb.	
w_s = Weight of steam not dissociated per lb. of dry coal, lb.	
T_p = Temperature of gas leaving producer, deg. F.	= 1108
t = Temperature of fire room, deg. F.	= 82

All the items of the heat balance will be figured on the basis of one pound of dry coal. The calorific value of the dry coal will thus be the heat supplied, if the sensible heat carried in by water, air, etc., is neglected.

Preliminary Calculations

The proximate analysis is generally expressed in percentage by weight of the coal, including moisture. To find the weights per pound of dry coal, it is necessary only to divide each of the items by 100 minus the percentage of moisture as reported. Thus,

$m = 2.75 \div (100 - 2.75) = 0.0283$ lb. of moisture;

$vm = 0.0617$ lb. of volatile matter;

$fc = 0.807$ lb. of fixed carbon;

$a = 0.132$ lb. of ash;

$vm + fc = 0.869$ lb. of combustible.

*Copyrighted, 1913, by Julian C. Smallwood, Associate Professor of Experimental Engineering, Syracuse University.

†Note that these results are given for the standard gas condition of 62 deg. F. and 30 in. of mercury, whereas the standard here used is for 32 deg. F. and 29.92 in. The volume per pound of the latter is 0.943 times that of the former. Also the specific heats of the gases are different, the values in this article being according to later authorities.

It is necessary to make an estimate of the total carbon in the coal, since the proximate analysis gives no value of the carbon contained in the volatile matter. This may be done according to the method suggested by Professor Marks (POWER, Jan. 14, 1913) for semi-anthracite and bituminous coals. For anthracite coals in these calculations sufficient accuracy is attained by taking the volatile carbon as 1 to 2 per cent. of the combustible when the volatile matter is from 5 to 10 per cent. Then, with the given data, the total weight of carbon in one pound of dry coal is

$$C_t = 0.807 + 0.01 \times 0.869 = 0.816 \text{ lb.}$$

The total carbon in the ash equals total dry refuse (ash + carbon) minus ash in 1 lb. coal times total coal as fired. It is uncertain, however, that all the ash from the coal consumed during the test is taken from the producer, so that it is better to analyze a sample of the refuse, for the amount of carbon in the refuse per pound of dry coal consumed is

$$C_a = \frac{\textit{Weight of dry refuse} \times \textit{weight of C in 1 lb. of refuse}}{\textit{Total weight of dry coal}}$$

In the test under consideration, each pound of the refuse was found to contain 0.388 lb. of carbon. The total coal as fired was 798 lb. Subtracting from this the moisture, which equals 0.0275 × 798, or 22 lb., the weight of the dry coal is 776 lb.; from which

$$C_a = \frac{85 \times 0.388}{776} = 0.042 \text{ lb.}$$

The carbon gasified is all of the carbon in the coal except that removed with the ash. Hence

$$C_g = C_t - C_a$$

for the given data, $C_g = 0.816 - 0.042 = 0.774$ lb. of carbon per lb. of dry coal.

The volume of dry gas generated per pound of dry coal should be calculated for a standard condition of pressure and temperature. The standard here used corresponds to 29.92 in. of mercury and 32 deg. F. Then

$$V = \frac{2980 \times C_g}{c}$$

the value c being found as shown in column (3) of Table 2, and the value $\frac{2980}{c}$ being the cubic feet of producer gas per pound of carbon in it. For the given data

$$V = \frac{2980 \times 0.774}{33} = 69.9 \textit{ cu.ft. per lb. dry coal}$$

The weight of the dry gas per pound of dry coal may be obtained from this if the weight of a cubic foot of the gas is known.

$$\textit{Weight per cubic foot} = 0.000028 \times p$$

the value p being found as shown in column (5) of Table 2. For the given data,

$\textit{Weight per cubic foot} = 0.000028 \times 2576 = 0.0721$ lb.

From which, the weight of the producer gas per pound of dry coal is

$$W_p = 0.0721 \times 69.9 = 5.04 \text{ lb.}$$

The weight of air Wa supplied to the producer per pound of dry coal is given by the formula

$$W_a = \frac{3.04 \times N_2 \times C_g}{c}$$

N_2 being the per cent. by volume of nitrogen in the gas as given in column (2), Table 2. For the given data,

$$W_a = \frac{3.04 \times 56.4 \times 0.774}{33} = 4.02 \text{ lb.}$$

The weight of steam, W_s, supplied by the vaporizer per pound of dry coal is found by dividing the total weight of water to the vaporizer by the total weight of dry coal. For the given data,

$$W_s = \frac{268}{776} = 0.345 \text{ lb.}$$

Coming now to the heat balance, the first item is

(a) *Useful heat in the cool gas.* This is exclusive of sensible heat if the gas is to be used for power, and is due to its calorific value when completely burned. The higher heat value will be used. Since all items of the heat balance are based on one pound of coal, the useful heat may be found by multiplying the volume of gas, per pound of coal, V, by the higher heat value in B.t.u. per standard cubic foot. The heat value may be figured as in column (7) of Table 2. This gives the values for the gas constituents, according to their amounts in one cubic foot, the sum of which is the required heat value. For the given data, the useful heat is 69.9 × 148 = 10,300 B.t.u.

The heat value of the dry coal was found to be 13,040 B.t.u., hence the "cold gas" efficiency of the producer is 10,300 ÷ 13,040 = 79 per cent.

TABLE 2. ANALYSIS OF GAS GENERATED DURING TEST, AND COMPUTATION OF QUANTITIES USED IN FIGURING RESULTS

(1) Constituents of gas	(2) Percentage by volume	(3) Subscript of C x (2)	(4) Molecular wt. of (1)	(5) (2)x(4)	(6) Higher heat value of (1)	(7) (6)x(2) / 100
CO	27.0	27.0	28	756	342	92.4
H_2	10.4	—	2	20.8	348	36.2
CH_4	1.8	1.8	16	28.8	1065	19.2
C_2H_4	0.0	0	28	0	1680	0
O_2	0.2	—	32	6.4		
CO_2	4.2	4.2	44	184.8		
N_2	56.4	—	28	579.2		
		c = 33.0		p = 2576.0		147.8 = higher heat value of gas

(b) *Sensible heat in the dry gas leaving the producer* equals

$$W_p \times \textit{specific heat} \times (T_p - t)$$

The weight of the dry gas has been previously figured.

The specific heat of producer gas varies greatly with the hydrogen content. Except for hydrogen the average specific heat of all the gases, exclusive of steam, may be taken as 0.26 for a temperature of 1100 or 1200 deg. F. The specific heat of hydrogen for these temperatures is about 3.72, so that even though its percentage by weight is always small, the effect of hydrogen upon the average specific heat of producer gas is very marked and varies with the amount of hydrogen present. The accompanying curve gives the average specific heats of normal producer gas with various percentages of hydrogen. For the given data ($H_2 = 10.4$) it is seen to be 0.288.

The temperature of the gas should be taken near the outlet at the producer with a suitable pyrometer. For the given data,

$$\textit{Sensible heat} = 5.04 \times 0.288 \times (1108 - 82) = 1490 \textit{ B.t.u.}$$

or

$$1490 \div 13{,}040 = 11.4 \textit{ per cent.}$$

(c) *Heat lost by excess of steam to the producer.* This is estimated from the weight of steam found in the gas per pound of dry coal, and equals

$$w_s \times \textit{total heat per pound of the steam}$$

The total heat of the steam may be taken with sufficient accuracy for this calculation, as

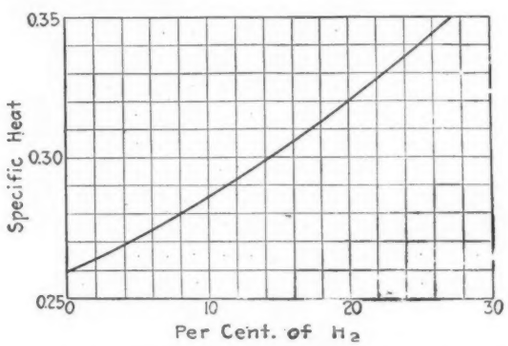
$$1000 + 0.5 \times T_p$$

For a more exact value, the expression quoted in the "Heat Balance of a Gas Engine" may be used.

To find w_s several methods are open. It may be measured directly by drawing a sample of the producer gas through a tube of calcium chloride, the increase in weight giving the moisture absorbed. The gas is siphoned into a container of known size so that its volume, and, hence its weight, may be obtained. w_s may also be figured from the hydrogen content of the coal and the gas. An easier method is based upon the fact that the sum of the weights of the gasified carbon, air and water vapor fed into the producer must equal the weight of the producer gas, including moisture. Hence,

$$C_g + W_a + W_s + m + \textit{vapor brought in with air} - W_p = w_s$$

The air vapor may be neglected here, although it may be a large percentage of the total steam, since its latent



VARIATION OF SPECIFIC HEAT OF PRODUCER GAS WITH DIFFERENT PERCENTAGES OF HYDROGEN

heat is not added by the coal. Then, for the given data,

$$w_s = 0.774 + 4.02 + 0.345 + 0.0283 - 5.04 = 0.137 \textit{ lb.}$$

from which the heat lost to the steam is

$$0.137 \times (1000 + 0.5 \times 1108) = 213 \textit{ B.t.u.}$$

or

$$213 \div 13{,}040 = 1.6 \textit{ per cent.}$$

Items (b) and (c) together equal the heat given to the scrubber plus that radiated between the scrubber and producer outlets. For comparison, or to get an estimate of the amount of sensible and latent heat in the gas without measuring it as just described, the heat added to the scrubber water may be determined. The water may be measured by a meter, and its temperature rise ascertained, as for the jacket water of a gas engine. In the test quoted the total weight of scrubber water was 22,200 lb. and its temperature rise was 45.8 deg. F. Hence, the heat given to the scrubber per pound of dry coal is

$$\frac{22{,}200}{776} \times 45.8 = 1310 \textit{ B.t.u.}$$

(d) *The heat lost to carbon in the ash.* Taking the heat value of carbon as 14,500 B.t.u., this loss, per pound of dry coal, is $14{,}500 \times C_a$. For the given data,

$$14{,}500 \times 0.042 = 610 \textit{ B.t.u.}$$

or

$$610 \div 13{,}040 = 4.7 \textit{ per cent.}$$

(e) *Radiation from the producer and other losses.* These may be grouped in one item by subtracting the previously calculated heat balance quantities from the heat supplied, or some of them may be separately determined. The loss by leakage of air in the case of a suction-producer plant may be found by comparing the useful heat, as herein calculated, before and after the dilution. In a pressure-producer plant, any leakage is apt to be detected; the only way to measure it is by metering the gas since leakage does not alter its composition. The loss due to tar and soot may be found by a special analysis of the gas as it leaves the producer.

Grouping these losses for the given data, we have

$$\textit{Radiation, etc.,} = 100 - (79.0 + 11.4 + 1.6 + 4.7) = 3.3 \textit{ per cent.}$$

Other efficiencies and results. The "hot gas" efficiency is often expressed when the gas is used for heating. In this case the sensible heat is also "useful." If, then, the first three items of the heat balance in per cent. are added, the result will be the hot gas efficiency. For the given data, this is

$$79 + 11.4 + 1.6 = 92 \textit{ per cent.}$$

The "efficiency based on combustible," corresponding to the boiler efficiency so known, is the efficiency that would be obtained if there were no loss of fuel in the ash, and equals

$$\textit{Efficiency based on coal} \div \left(1 - \frac{C_a}{vm + fc}\right)$$

the quantity in the parenthesis being the efficiency of the grate, or cleaning. For the given data, this efficiency equals

$$79.0 \div \left(1 - \frac{0.042}{0.869}\right) = 82.9 \textit{ per cent}$$

for the cold gas.

For purposes of comparison of tests with different kinds of fuel, it is useful to obtain the volume of gas per pound of combustible. This equals

$$V \div (vm + fc).$$

In capacity tests, the output may be measured in cubic feet per hour by multiplying V, as herein calculated, by the weight of dry coal used per hour.

For pressure producers it is necessary to account for the coal used in the auxiliary boiler to make steam. This may be included in the total coal charged against the producer, and another item added to the heat balance to account for the heat used in the steam-making process. Or, from the volume of gas generated there may be subtracted an amount equivalent to the steam supplied, which does not seem to be so logical a process.

For bituminous producers, if much carbon disappears as tar, it is necessary either to meter the gas to get V, or to determine the amount of carbon going to tar from one pound of dry coal, by analysis of a sample extracted from a measured volume of gas. From this result it is possible to obtain a more correct value for the amount of carbon gasified.

The heat balance may be extended to cover the distribution of heat in a gas engine supplied by the producer, by the methods indicated in the article covering this subject. In this case, the gas need not be metered since the fuel quantities are measured in the coal, and the heat quantities should be based upon one pound of dry coal instead of one cubic foot of gas. The exhaust losses as calculated in the previous article may be readily changed to the coal basis by multiplying them by V as herein obtained.

REFRIGERATION DEPARTMENT

Refrigeration a Desirable Load for Central Stations*

During the last few years central-station men in all parts of the country have come to understand the marked effect that a high annual load factor has on reducing unit-output costs, and are desirous of securing those classes of business which will tend to bring up load factor. One of the important lines of business which comes under the above head is that of refrigeration. Up to comparatively recent times refrigeration has been confined to large steam-driven plants used in either the manufacture of ice or in cold-storage warehouses. The advent of the electric motor and the availability of central-station service at all hours have made possible the wide use of refrigerating apparatus, so that at the present time it becomes a part of the standard equipment of practically every class of modern building.

A more recent development of the use of central-station power in this class of business is in connection with the manufacture of ice in large quantities, and this is an important field for central-station exploitation, as it involves the use of large blocks of power during off-peak hours, and at a high annual load factor. This has already reached such proportions that last season in one city alone there was manufactured 100,000 tons of ice with central-station power.

In the last year's report of the committee it was pointed out that there are in the United States about 2000 steam-driven ice plants, which, if operated by central-station power, would mean a consumption of from 600,000,000 to 700,000,000 kw.-hr. per year. The probabilities are that there will be a steady increase in the number of ice plants.

Advantages of the Electric Plant

One of the principal advantages of the electrically operated ice plant is that it may be built at or near the center of the territory to which it is to supply ice, irrespective of railroad facilities. This is an important point, as a large item of cost in the ice business is that of delivery to the consumer. The ideal arrangement is to install plants of from 80 to 100 tons capacity about two miles apart, so that each plant will supply the territory within a radius of a mile, thus reducing delivery to a minimum. One other point of advantage is that better ice can be produced, as the trouble frequently encountered in steam-driven plants of having oil carry over from the engine cylinder is eliminated.

Ice Making

It might be well to point out a few physical facts in connection with the manufacture of ice.

Chemically-pure water free from air will freeze solid and clear.

Water containing impurities in solution tends in freezing to force these impurities out of solution. The slower the process of freezing the more completely is the purification effected.

Ice formed in still water sends out long, slender crystals, which increase in number and size, forming a meshwork which gradually becomes a solid mass.

Agitation of water during freezing aids in the separation of impurities and is, therefore, of value in the forming of solid, clear ice.

Practically all natural waters contain air and more or less organic or inorganic material in solution. These substances tend to cause the ice formed to be opaque, but as they are frozen out of solution, those that are light rise and collect near the surface, and heavier ones stay near the bottom.

The rate of ice freezing increases as the thickness already formed increases. The time required to freeze increases as the square of the thickness to be frozen. The formation of natural ice is from the top down and impurities frozen out of solution fall. This and the motion of the water, especially in quiet-running streams, tend to make natural ice transparent. American manufacturers of ice have always tried to duplicate this clearness, although in foreign countries opaque ice is frequently used commercially.

Distilled Water Ice Making

From the foregoing it will be noticed that distilled water will freeze solid and practically clear. This is doubtless one of the main reasons why such a large number of plants now in existence are making ice from distilled water. The plan was to utilize the condensed water from the engines for a large part of the distillate. It might be thought by a casual observer that this was an ideal arrangement against which purchased power could not compete. The situation has been met, however, in two ways, (1) by making raw-water ice, i.e., freezing the water without first distilling it, and, (2) in cases where distilled-water ice is desired, by securing the necessary distilled water by means of a multiple-effect evaporator. This is an efficient piece of apparatus for securing a high evaporation of water per pound of coal. With this apparatus six times as much water can be evaporated per pound of coal as with the ordinary boiler. To secure this result, advantage is taken of the fact that water will under vacuum evaporate at a much lower temperature than under ordinary conditions.

Evaporators for ice-plant work are classified broadly into two types—exhaust and high pressure. In a standard noncondensing steam-driven ice plant the losses vary from 10 to 20 per cent., and, hence, 100 tons of distilled water in the cans means at least 115 tons produced or handled. Of this amount the compressors and auxiliaries will furnish not over 90 tons; hence a makeup of 20 to 25 tons must be bled from the boilers at the average rate of evaporation of the plant. The exhaust-steam evap-

*Excerpts from report of the Committee on Refrigeration read before the National Electric Light Association, Chicago, June 2-6, 1913.

orator in single effect with an economy of eight tons of distillate per 10 tons of steam, supplies this makeup with a consequent direct saving in coal represented by this evaporation in the boiler less pump charges. With two-effect plants operating from a few pounds above atmosphere to, say, 25 in. of vacuum, the economy may be increased to a ratio of 2¼ to 1 of steam.

If the plant be put upon a standard compound-condensing basis a still greater deficiency exists, say, 60 per cent. of the total coming from the evaporators, and the cost of production is still more against central-station power. Evaporators for the service may be two or more effects, depending upon the price of coal. Their economy may run to as high as 5½ to 1.

For motor-driven ice plants the problem is to produce the distilled water as cheaply as possible, and resolves itself into a consideration of capital investment versus efficiency, and the governing factor is usually the price of fuel. With motor-driven pumps, an eight-effect plant will give an economy of 6 to 1, and, hence, produce with average Western coal and boiler performance, 45 to 48 tons of distilled water per ton of coal. It is seldom economy to exceed eight effects.

REPRESENTATIVE ICE PLANTS USING CENTRAL-STATION POWER

Plant	Rated Capacity per Day Tons	Total Connected Load Hp.	1912 Data Yearly Kw. Maximum Demand	Rated Capacity Maximum Demand per Ton, Kw.	Yearly Ice Output Tons	Annual Kw.-hr.	Average Kw.-hr. per Ton of Ice	Months of Operation
DISTILLED-WATER PLANTS (CAN PLANTS)								
Knickerbocker Ice Co., 61st St. Plant, Chicago	120	564	364	3.0	37,205	1,457,912	44.7	8
Knickerbocker Ice Co., 65th St. Plant, Chicago	90	375	248	2.7	9,005	568,824	63	5
Englewood Distilled Water Ice Co., Chicago	80	302	236	3.0	8,651	487,658	56.3	5
Webster-Citizens Co., Mechanics St. Plant, Buffalo, N. Y.	90	427	230	2.5	33,002	1,444,608	43.7	12
RAW-WATER PLANTS (CAN PLANTS)								
Lincoln Ice Co., Chicago	120	511	362	3.0	27,839	1,455,012	52.2	12
Crystal Ice Co., Chicago	60	235	233	3.9	9,656	622,186	64.5	10
RAW-WATER PLANTS (PLATE SYSTEM)								
Crystal Ice & Storage Co., Buffalo, N. Y.	130	352.5	297.4	2.3	16,243	938,100	57.7	12

Raw-Water Plants

To do away with the necessity of using distilled water, many raw-water plants have been built and are giving good results. One of the items which must have an important bearing will be the character of the water supply. In some sections of the country where the water contains a large amount of mineral substance in solution, it may be difficult to secure clear raw-water ice, but ordinarily there is very little difference in the appearance of distilled-water ice and raw-water ice as manufactured in the best plants.

The methods of manufacture of raw-water ice can be classed under two general heads—the first known as the can system and the second as the plate system. Most of the plants now in operation are of the can type, although there are a few of the plate variety.

Can Plants—In a can plant the ice is formed in large cans in which filtered raw water has been placed, these cans being immersed in tanks of refrigerated brine which is being constantly circulated by means of pumps. During the process of freezing, the water in the cans is agitated by means of compressed air to secure clear ice. The water in the cans is permitted to freeze until the core is reached, at which time the core water is replaced by distilled water and the cake frozen solid, leaving simply a feathery effect through the middle of the cake. This removal of the raw water from the core is necessary to secure a clear cake of ice, as it would be impossible to agitate the raw water until it is entirely frozen. Then, too, the water which has been removed from the core contains practically all of the impurities from the entire can. This process involves the use of between 15 and 20 per cent. of distilled water which can be supplied by means of a small multiple-effect evaporator, such as is used in regular distilled-water plants.

Plate Plants—In the plate type of plant hollow plates through which cold brine or ammonia can be made to circulate, are immersed vertically in tanks filled with water which is agitated. The ice forms gradually on both sides of the plates, thus ridding itself of any air or other impurities on its surface. In the can system these impurities concentrate toward the center, forming an impure core which is removed as previously explained. With the plate system it is not necessary to distill or boil water which is otherwise pure for ice making. The plate plant however, requires more skill to manipulate it successfully, and is more expensive to install and keep in repair.

In this system when the ice is formed to the desired thickness (usually about 12 in.), it is loosened from the freezing plates by various thawing arrangements. The ice cakes, often 9x16 ft. by 12 in. in thickness, are lifted from the tanks by overhead cranes, and are carried to a table where they are cut to commercial size.

Motor Drive

In order that the successful operation of an electrically driven ice plant may be assured, it is necessary that a proper equipment be installed. One of the important features is the type of motor to be used. In all probability the great majority of the plants to be considered will be located in territory in which the central-station supply is alternating current; in fact, all of the large plants thus far constructed have been equipped with three-phase motors. There is some difference of opinion as to whether motors should be designed for constant speed or variable speed. In any event, they should be of the slow-speed, slip-ring induction type, and equipped with drum controllers. In case constant-speed work is desired, the resistance to be furnished with the controller need be large enough simply for starting the motor. If at a later time it becomes desirable to operate the motor at variable speed, the only change required will be to install additional resistance. The use of multispeed motors has been suggested for this class of work, but it was the opinion of the committee that this practice should be discouraged, as the efficiency of the motor at full load is not quite

as high as the standard motor, and, furthermore, the power factor is considerably lower.

Voltage of Motor

While some of the companies have adhered to the standard practice of using 220-volt motors, others have adopted the plan of operating the large compressor motors at primary voltage of approximately 2300 volts, using lower voltage on motors operating the auxiliaries. The efficiencies of three-phase motors are the same at either 230 volts or 2300 volts. The factors involved in making a choice are the economies in operation due to the elimination of transformer losses, and the comparative costs of first installation. The use of primary voltage on motors, however, introduces a risk to attendants which many of the large companies hesitate to assume.

Comparative Operation—Steam and Electric

The question is often asked whether or not an electrically operated plant can be made to operate as cheaply as a steam-driven plant when the location is favorable to the steam plant, that is, when ample railroad facilities are available so that coal can be brought in under the best conditions. The question is best answered in the words of one of the largest ice operators in the country, who has a number of distilled-water ice plants, both steam and electric. He states that under his conditions of operation there is practically no difference in the cost of manufacture under the two systems. Under the electric plan of operation, however, he can locate plants to best suit his needs.

Operating data on typical electrically driven ice plants will be found in the accompanying table.

❋

One Cause of Decreased Output in Ice Plants

By Peter Neff

It sometimes happens in an ice-making plant which operates on what is termed the flooded system, that the capacity falls off without apparent reason. The engineer is sure the system is working perfectly, that frost shows at the feed valve, and all other conditions seem to be as usual, and yet the capacity of the plant has decreased. From my experience this trouble is most frequently the result of a very simple cause.

As is well understood, the production of the cold is brought about by the absorption of what is termed latent heat, in changing the liquid ammonia into a vapor; the heat required being taken from the medium surrounding the evaporator, thus cooling it. And, further, that if in place of liquid ammonia being introduced into the evaporator, there be uncondensed ammonia vapor, this vapor when it encounters the low temperature will condense, and in doing so will impart to the evaporator the latent heat which it contains. The evaporator will become heated, resulting in the failure of the system to produce any useful work. Such a condition would be quickly apparent to the engineer in charge.

On the other hand, if, while the plant is running continuously, the production is normal and the system in proper condition, there is supplied to the feed valve a mixture of liquid and vapor, what is the result? Suppose that for every 10 lb. of ammonia supplied to the feed valve that 9 lb. is liquid and 1 lb. vapor. As this mixture passes into the evaporator a portion of it is evaporated in cooling what has been introduced at the temperature of the condenser down to the temperature of the evaporator; this is the dead work that always has to be done on the liquid ammonia, and is the reason why it is desirable to have the liquid as cool as possible when it reaches the feed valve. In the case where liquid only is supplied to the feed valve, the loss incident to cooling it is provided for in the size of the compressor. This loss is bad enough but in the case taken there is an additional loss, for the 1 lb. of vapor has to be condensed and the heat which it contains must be taken up by the evaporation of a part of the liquid ammonia, in this case amounting to about a pound, so that the available work of the 10 lb. introduced has been reduced some 10 per cent., and this loss is at the expense of compressor energy. Thus while the compressor and other parts are doing their full duty the capacity of the plant falls off.

Just what percentage of the amount passing the feed valve can be vapor and yet the condition of a frosted feed valve be maintained, cannot be stated, but I have known of plants where the production fell off over 10 per cent. and still the frosted condition of the feed valve remained. This frost, however, to the observant eye showed a marked difference when nothing but liquid was passing through.

This condition of mixed vapor and liquid results from practically all the liquid being withdrawn from the receiver, at least enough to allow the outlet opening to be at times partially exposed. There are a number of ways in which this condition may occur. An engineer will get careless about watching the feed valve, and while the flooded system does not require the close attention that the expansion system does, yet it is not automatic. Now a feed valve may be so set that it will be hours before the condition referred to begins, at first very slowly, then faster and faster, until after a while the engineer notices that his tank temperatures are rising. If it has gone so far that the frost has left the feed valve he will be quick to notice what the trouble is. If not, he may blame it on the puller or the firemen, or just to pure depravity of the plant.

Where the charge of ammonia is low, this trouble is more likely to occur. A change in condenser pressure effects it, for the greater the difference between the high and low pressures the greater will be the flow through a given sized opening. Where the engineer has a gage-glass on the ammonia receiver, and this is watched, there is little likelihood of this trouble arising. It is such a simple trouble that one would hardly suppose it could frequently happen, yet it does to the discomfort of the engineer and the financial loss of the owner.

❋

A new method of removing hard scale from boilers is described in "Engineering." The apparatus (known as the "Pyro" boiler cleaning system) used consists of an oxy-acetylene blowpipe with two or three jets, a portable acetylene generator, a steel cylinder of compressed oxygen, and the necessary length of flexible tubing. When it is desired to remove any scale, the blowpipe flame is played upon it for a few minutes (depending upon the thickness of the scale) until the scale cracks and falls off due to rapid expansion under the high temperature. If the scale is slightly damp, the operation is assisted. Care should be taken to keep the flame from playing on the bare plate for any length of time. One of the advantages claimed for this method is that it can be easily applied to parts of a boiler where hand chipping is impossible.

EDITORIALS

When and What To Accept

A firm permits a man to purchase supplies and to select and have charge of new equipment for two reasons: First, because it believes his skill and experience fit him to better select than others in the firm's employ. Second, because it believes he will select honestly, i.e., that he will not allow his judgment to be warped or influenced by the "presents" and "tokens of appreciation" offered by bidders or those seeking to sell goods.

It is so easy to accept things you should not accept from persons with goods to sell. First you take a cigar; there is no harm in that. Then, perhaps, you are speaking of some peculiar steam troubles to a representative and he tells you that just that very subject is covered by a certain book and that he will be glad to mail you a copy. If your employer were in the office with you, you would not be ashamed to let him see you take a cigar or accept the book. But, suppose the coal dealer were sending coal to your house in return for the privilege he enjoys of supplying the plant with coal? You would not want "the boss" to know about that.

Do not accept anything that you would not want your employer to know about. That is a safe rule to follow.

❖

Cinder Arresters in City Plants

With the increasing use of mechanical stokers, low-grade coals and the high draft necessary for economical combustion and overloads, the smoke and cinder nuisance becomes greater.

Smoke and cinders emitted from the stacks of industrial and central-station plants located in cities, not only pollute the atmosphere of the neighborhood, ruin clothes and deface architecture, but in many cases, particularly industrial centers, spoil the product of adjacent mills or factories. Textile mills, chemical works and factories making foodstuffs cannot be run well with closed windows during the summer, but chronically smoking stacks in the vicinity often make this necessary, much to the discomfort of the employees and consequently the output is decreased.

With the use of high draft and low stacks, both common in these days, this evil is augmented. Smoke-inspection laws and the intelligent coöperation of the smoke-inspection department does much to minimize the evil in any locality.

Cinder or spark arresters, placed in the stacks or main flues, while not a panacea for all smoke troubles, are effective in reducing the evil below the level of a nuisance. They are not complicated, their operation usually consisting essentially of passing the smoke and gases through a water spray, after the manner of the scrubber of a producer-gas plant or the air washers of some ventilating systems.

These arresters require so much water that usually they are not found in plants not adjacent to a source of cheap water supply. Unlike most apparatus, however, they do not require clear, clean water, and it is easily possible to return the water to the arrester after it has been separated from most of the combustion products. Possibly there is a serious objection to doing this. The sulphur dioxide formed during the combustion of the coal forms sulphurous acid when it unites with water. This acid is injurious to metals and when oxidized to sulphuric acid becomes more so. It may be, therefore, that this returned water would soon become such a corrosive agent as to be unfit for such use.

Much has been done of late years to design and construct boiler furnaces that will, with ordinary care, quite thoroughly combust fuels and thus keep down to a minimum the production of smoke. Cheap coals will be used, especially by big consumers, who are the ones to violate smoke ordinances most frequently. It is sometimes cheaper to pay the occasional fines imposed by the smoke inspection department than not to attempt to find means of burning a cheap and low-grade coal without more smoke and cinder than is allowed by the inspection department.

Usually cinder arresters are the only apparatus that make this commercially possible. If, therefore, a plant is in the congested part of the city and considerably distant from the ocean, lake or river front, and such a plant is a large consumer of coal and an old offender of the smoke ordinances, the city might find it expedient to supply water to the cinder arresters, through a separate meter and at a reduced rate.

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Boiler Inspection in England

The annual report of the management of the Manchester Steam Users Association for 1912 has just recently been issued and noted in POWER of June 10. The association is the first of its kind. It was founded by the late William Fairbairn in 1854, and the number of boilers under its supervision is 10,051 at 4564 works. The average income per boiler is about ten dollars and considerably over ninety per cent. of the boilers receive full examination throughout every year. The association conducts its affairs in lines very different from the insurance companies. It does not insure boilers, but inspects, reports and advises. If the owner follows advice up to a sufficient degree of compliance the association backs its inspection with a pecuniary guarantee of $5000 to $10,000, thus indorsing its inspection and offering to fine itself should a guaranteed boiler fail.

If advice is not well followed the association does not reject the boiler. So long as the fee is paid the inspections are made and the advice is hammered in, but the guarantee is withheld. When a boiler explosion was classed as among "the acts of God and the king's enemies" the withholding of the guarantee did not trouble some boiler owners very much. But today boilers cannot explode without an inquiry. And it is not even necessary

that anyone should be either hurt or killed. The inquiry follows just the same, though a fatality is apt to intensify the inquisition.

A boiler-explosion inquiry is usually a silly affair conducted perhaps by a man of no technical knowledge, who listens patiently to wigged barristers, who often do not know a rivet from a firehoe. But a considerable degree of publicity obtains and it comes to the surface if the owner has neglected the warnings given him by the inspection or insurance companies, and those who are responsible are charged to pay part of the costs of the inquiry and may even be indicted for manslaughter.

This and the thoroughness of boiler inspection may partly account for the high degree of safety secured, for only nine persons were killed by actual boiler explosions in 1912 and twenty-five were killed by steam pipes, kiers and sundry other explosions, whereas twenty persons were killed in October alone in the United States.

There cannot now be many boilers in Great Britain, which have not the rank of modern, for steel plates and drilled rivet holes after bending have been in vogue over 30 years, and the age of a boiler is rated at 25 years. The rise of pressures has helped to put most elderly boilers out of commission.

Whereas the methods of the association have set the tone in boiler-inspection work generally, yet the guarantee as opposed to insurance has not made much headway. The insurance companies carry on their books many times the number of boilers carried by the associations and have done good work, though occasionally they have lapsed somewhat for the sake of retaining business. Boiler owners have been prone to balk under the pressure brought to bear on them, and to retain their business too much leniency has been shown them in the way of excessive delays in canceling policies where recommendations are not followed. With the association there is no cancellation of policy, but simply a delay in giving the guarantee until the boiler and all its appurtenances are judged satisfactorily.

In the past the insurance companies through the competitive dickering which went on were exposed to conditions far from desirable. There is perhaps less of this now to contend with for it has ceased to be safe to take business on the basis of insufficient inspection or lenient rules of safety.

American coroners might well gain a few pointers from the above procedure. It is far from right to blame the dead engineer or fireman for an explosion for which the owner may be directly responsible. A few indictments at the right time and against some of the men higher up would have a desirable effect in tending to reduce the annual number of boiler explosions.

❋

Unjust Criticism of Boiler Inspectors

Once in a great while we receive letters from disgruntled engineers, criticizing the work of boiler inspectors. Usually such letters are vehement and explosive in their condemnation of all boiler inspectors in general. If such communications were received frequently there would be reason to believe that the conditions they portrayed were actual.

The insurance boiler inspector is selected with great care. He must be not only a man who knows boiler-inspection work, but one who realizes that much depends on the thoroughness with which he performs his duties. Companies insuring boilers select their inspectors from among trained inspectors, foremen of boiler shops and from among high-class steam engineers.

It would indeed be difficult for an incompetent man to become an inspector. If he did get the job he would find it more difficult to hold it than he did to get it. Occasionally one is found who is negligent and he is promptly discharged when his company learns of it.

The number of inspections and visits made in a year in any particular locality depends on the law governing inspection in that locality. Where no state or municipal laws exist or where they are lamely enforced the number of inspections and visits is usually greater than where inspection laws are strictly enforced.

Usually, in any locality there are at least two inspections, one internal and one external, and the inspector visits a plant about four times a year.

Some engineers—the ones who write letters, such as referred to above—believe that the inspector should inspect the boilers every time he calls. They do not know that he calls to survey the morale of the force and the general condition of the plant. Consequently when they see him walk out without having crawled into the boilers they condemn him for performing perfunctory service.

Engineers who believe that the boilers under their charge are not being properly inspected should communicate with the insurance companies to adjust matters before they unjustly condemn the boiler inspectors. Gladly will we expose inspectors guilty of serious negligence or incompetence when specific evidence is furnished, but it would be obviously unfair to censure the whole profession on account of the shortcomings of a very few.

❋

Uplift the Boiler Room

It is rather remarkable that so little attention is given by designers of average steam plants to introducing devices for removing ashes, which ordinarily is one of the most disagreeable and laborious tasks in the boiler room. While some attention is generally given to convenient handling of fuel, it is the rule rather than the exception that accumulations in boiler ashpits are permitted to be the source of most of the grime and dust that go to make the contrast in cleanliness between boiler plants and well kept engine rooms.

Progressive employers are not slow to recognize that lightening labor and improving the appearance of surroundings redound to their profit as well as the benefit of their employees, though suggestions of such improvements naturally must have their origin in the employee, and he will generally find those propositions most readily acceptable to his employer which promise a saving of money. No operating engineer or fireman need hesitate to recommend improvements that are money savers, but before proposing the installation of anything which is generally neglected he should be prepared to make its economic advantages clearly evident to the investor.

Any fireman or engineer who is tired of the old way of removing ashes from his boiler room should investigate every available mechanical means for doing the work. Then, obtaining estimates of cost of installation of the proper appliances, he can approach his employer with a money-saving proposition.

READERS WITH SOMETHING TO SAY

Hot Piers Prevent Smoke

This plant is located in the heart of the retail district, and is surrounded by business blocks, some of which are several stories higher than the one in which this plant is located; hence our trouble. Every time any smoke comes out of our stack our neighbors who have more time than business on their hands call up the city hall and register a kick about our stack. You all know that means trouble. We have 300-hp. Heine-type boilers, but only use one at a time. Our stack is 48x48 in. at the top and 160 ft. high. The draft over the fire is $^{23}/_{100}$ in., which, for the size of the boilers, is very low. We removed 12 in. of the lower baffle and the same amount of the top one (the baffles are horizontal). The reason for removing a part of the baffle is to increase the draft, which we did to $^{27}/_{100}$ in. We then put three brick piers in the furnace, being careful to have the space around them larger than the throat opening into the breeching. We have had no complaints since.

The function of these piers is to retard the flow of the gases and give them a rolling or whirling motion; they also serve to help burn the carbon carried off with the gases, as they are heated to a very high temperature. Two of the piers are set on the bridge-wall and are 18x24 in., and extend up within 1 in. of the tubes. The front pier is 24x24 in., and sets 22 in. ahead of the bridge-wall directly in front of the other two. With our type of stoker (sloping side grate) there is now no straight passage for the gases, and as they come in contact with the hot piers they are given a whirling motion and are also retarded a sufficient length of time to allow all, or nearly all, the carbon to be consumed. We also increased our evaporation about 1½ lb.

O. N. Pomeroy.

Lakewood, Ohio.

Worm-Gear Lubrication

There is a tendency to regard a worm gear as a suitable case for lubrication with thick, viscous oil, but in one instance the opposite was the case. A feed pump was driven by an electric motor through a worm and wheel; although the worm box was filled with a thick oil, after running for some time, the exterior of the casing about the thrust bearing became very hot, although the thrust was also immersed in oil.

While watching carefully, with a view to stopping the pump because of this heat, the casing became cool with almost startling rapidity. The heat had rendered the oil limpid and enabled it, presumably, to circulate better under the influence of the worm rotation and to flow not only more freely to the thrust bearing, but to work into both worm gear and thrust flanges. Thus the limpid oil better performed the duty of reducing friction than the thick oil.

In Lancashire cotton-mill practice the bearings of the rope-pulley shafts are supplied with a continuous flow of oil forced by centrifugal pumps. All these bearings are piped back to returns and the oil is filtered on its way back to the pump.

Can it be shown microscopically or by friction tests that such oil is any worse for a thousand passes through a loaded journal so long as the metallic or other impurities are filtered out? Oil is, when organic in origin, presumably built up of organic cells. If this is so, it is possible that its texture may be injured by heavy pressure on thin films. It does not seem possible to in any way injure the texture or nature of water having no organic structure. Unless overheated, oil has been regarded as equally nondamageable, except by absorption of oxygen. Is there not room for doubt on the subject, or has oil been so tested that it may be considered stable under stress?

William H. Booth.

London, England.

One of Many

One of the constantly occurring instances of old boilers being used under criminally dangerous conditions recently came to my notice. I was staying at one of the few hotels of which the town boasted. While in conversation with the porter he remarked upon the antiquity of the boiler used for heating the place. Being interested in steam plants of any kind, I persuaded him to let me have a look at the "plant."

I found a roaring fire underneath a boiler, which on looking at the gage-glass and trying the cocks, proved practically empty of water. The fire was immediately drawn. Investigation afterward showed that one of the return pipes of the heating system had frozen during a cold snap, and on the return of mild weather one of the pipes had burst, letting all the water out of the system.

The porter being new on the job, supposed that the boiler was under city pressure all the time, and that the water level was automatically maintained. He, therefore, had not touched the feed valve since his arrival about a week previous.

The boiler was 48 in. by 12 ft. and about 30 years old, and in that time had never to anyone's knowledge been cleaned. Imagine the amount of scale which would accumulate in that time with the use of city water remarkable for its hardness. Not only was the location of the safety valve unknown to the present owner, but he confessed ignorance as to its purpose. All the cocks and connections were leaky and most of the valves and cocks were minus handwheels, for which gas pliers served as a substitute. The steam gage was merely an ornament for I am confident that it had not moved from the zero mark in years.

If the boiler does not blow up in the mean time, a modern heating system will be installed this summer.

R. E. Durland.

Toronto, Ont., Canada.

Increases Feed Water Temperature

In a plant in which I was employed recently, the valve *A* was an ordinary globe valve. At that time, the exhaust from the main engines was run as follows: Valve *D* open, valves *C* and *E* closed, the steam going direct to the condenser. The auxiliary exhaust led through the heater and a bypass valve *A* to the atmosphere. With this arrangement, the feed-water temperature averaged 196 deg., which average we decided we could improve, and we made the following alterations:

The locknut on the inside end of the thread bushing in the yoke of the valve *A* was removed, thus allowing the valve to be operated without turning the stem, the thread bushing working back and forth in the yoke. All but one turn of the valve-stem packing was removed; a lever and weight were fitted, as shown, and a hole drilled and tapped in the valve bonnet, and a drain *F* connected to carry away the water that collected. Provision was made to obtain a higher back pressure than usual before opening. A steam gage was connected, as shown, and the drains from the heater and exhaust lines led to a trap sunk in the floor of the pit. The weight was adjusted until 7 lb. back pressure opened the valve *A*. With this arrangement, we obtained an average feed-water temperature of 206 deg., the temperature rising at times to 224 deg. The temperature was taken hourly and averaged for the 24 hours.

HENRY C. BRIGGS.

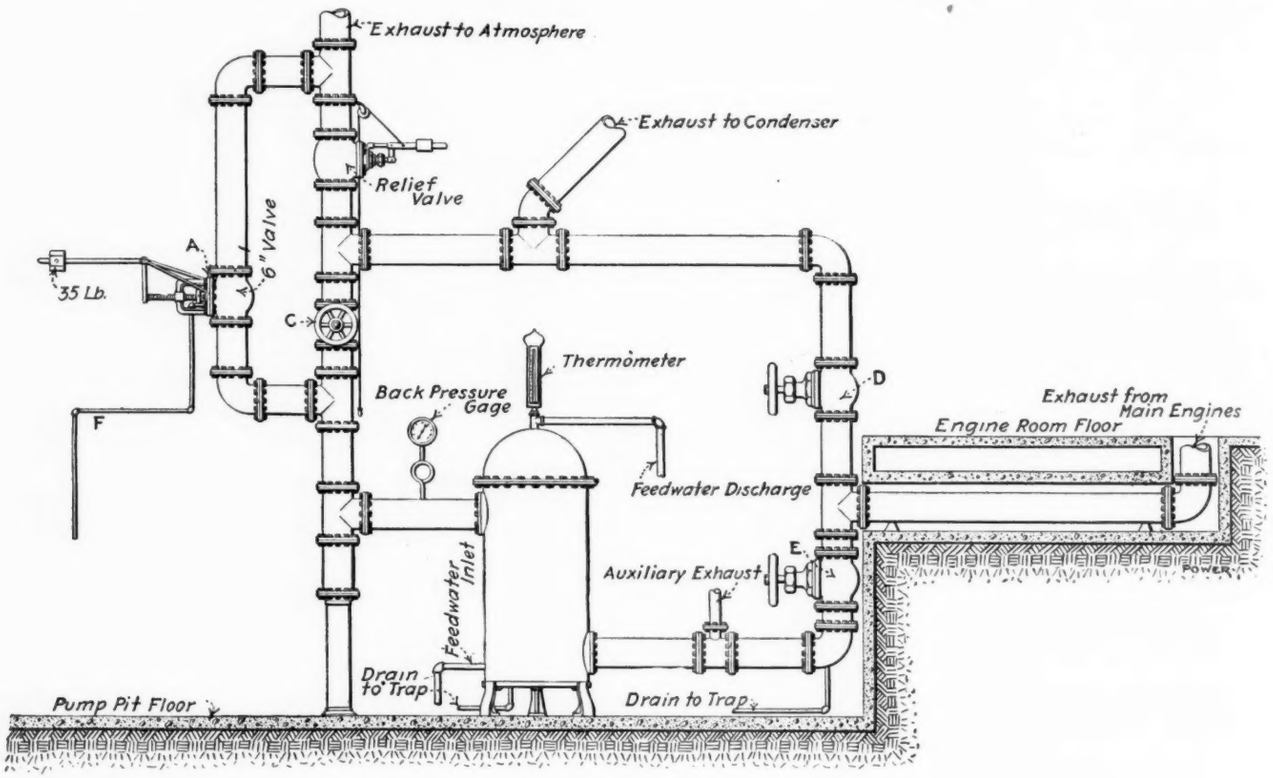
Jersey City, N. J.

[The pressure corresponding to a temperature of 224 deg. F. is 18.56 lb. abs., or 3.86 lb. gage; Marks & Davis Tables.—EDITOR.]

Steam Gages Inaccurate, Due to Plugged Pipe

In getting up steam one Sunday after cleaning the boiler, the engineer was surprised to hear the safety valve blow when the two steam gages showed only 35 lb. pressure with the valve set to blow at 120 lb. The valve closed as usual in a short time only to reopen when the gages indicated about 50 lb. pressure. It continued to act in this manner until the gages showed 120 lb., when everything went along as usual. The gages and safety valve were closely watched the rest of the week, but showed no signs of giving trouble. The following Sunday the valve was removed and taken apart, but everything seemed to be in good order. On getting up steam again the safety valve commenced to blow at about 35 lb. pressure as before and continued to blow at about every 15 lb. increase until 120 was indicated by the gages. It was then decided that the springs were at fault and new ones were ordered and put in place. The new springs did not remedy the trouble, so the boiler inspector was called in.

He examined the valve and tested the gages and found them correct. The boiler was fired up again and acted as it had before. The test gage was then applied to a ½-in. pipe on top of the boiler and registered 120 lb. while the other gages only showed about 75 lb. This gave a clue to the cause of the trouble, which was found to be in the ¼-in. pipe to which the gages were connected. One gage was located above the water column while the other one was at the side of the boiler wall, both being attached to pipes leading from a tee connected by a short nipple to the top of the water column. This nipple had



PIPING TO HEATER, CONDENSER AND THE ATMOSPHERE

been cut with a three-wheel pipe cutter and put in place without having had the burr removed from the inside of the pipe. This had reduced the opening about one-half, which gradually closed up until the gages could not record the pressure as fast as it increased in the boiler.

The pipe was replaced with new pipe reamed out to full size at the ends and the gages and the valve gave no further trouble.

E. E. Sidinger.

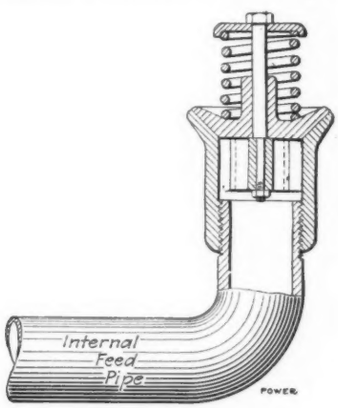
Salem, Ohio.

[Such experiences as the above serve to indicate the importance of keeping a strict check on one's gages and safety valves. It is a serious situation when a boiler has full pressure on it before the gages show it, even if it is equipped with a safety valve.—Editor.]

Makes Internal Feed Pipe

I had been considering the various arrangements of internal feed pipes to fit to my boiler, and I was aware that there were some objections to the use of a pipe delivering water into the steam space through perforations. The holes have to be large to provide against being blocked by sediment, etc., or the possibility of rupture by water-hammer.

For those reasons I decided to use a spring-loaded relief valve on such a pipe. My experience with the check valve showed that more pressure was necessary on the internal pipe to spray the water and this led to my conception of the arrangement shown in the sketch, which is a mitred valve with a wide seat. The spring used is an ordinary spiral one. This valve could be made in commercial sizes to screw onto any black-iron pipe. The idea is to maintain a pressure on the water to the point of delivery which would have the effect of delivering the feed into the steam space in the form of an umbrella spray. A thin film of water absorbs the heat of the steam before coming in contact with the water surface, thereby enhancing the circulation.



Spring-Loaded Valve on Internal Feed Pipe

G. P. Melligan.

Leva, Fiji Islands.

Engineering in the Mining Country

About two years ago, having tired of the engine room, I decided to take a six months' ramble through the mountains of Nevada County and Sierra County, and ran across several mines and numberless "prospect holes." The plants at two of these were about the worst examples of engineering that I have seen for some time.

The first was located on Deer Creek, the hills on either side being about 400 ft. high. A tunnel was driven through the hill about 300 ft. above the mine and by means of a ditch and flume about 10 miles long, water was obtained for an undershot wheel connected direct to an air compressor; this, in turn, was the means of operating the hoist and also the drilling machines and pumps below ground. When I arrived they were just about ready to start up, and the next morning a man was sent up to open the gate at the tunnel.

All went well when starting, but after running about two hours they shut down to fix some leaks in the pipes. When starting up the second time with 100 lb. in the receiver the compressor refused to start and the man at the wheel of the gate kept opening up until the stream from the nozzle was strong enough to overcome the opposing force. I told the superintendent that what was needed was a connection whereby they could start the compressor against atmospheric pressure, instead of 100 lb. He replied that the man who had installed the plant had made a business of that kind of work for the past five years, and if he did not know how to set up a compressor he guessed no one did.

Later I learned that in starting up against 100 lb. pressure the waterwheel had gone to pieces, wrecking the compressor and depositing part of the remains on the other side of the creek.

About a month later I came across a small mine almost hidden in the timber. The hoist was of the vertical single-cylinder friction-drive type and with the exception of the engine was home-made. I believe the drum had been made out of the spool that the hoisting cable came on. An ordinary globe valve served as a throttle, and this was in such a position that the brake and clutch levers could not be reached from the throttle.

As I entered, the engineer had just received a signal to hoist. He got the engine up to a fair speed, then threw in the clutch and released the brake and jumped for the throttle, gave the engine more steam, then dropped down and helped on the flywheel until the speed picked up a little. He had to hoist a car about every 30 min., and while he was sharpening some drills in the blacksmith shop later on, he told me that on the first day (he had been there three days) he had experienced trouble several times when he failed to get to the throttle before the engine stopped and had to jump back and apply the brake, as the car had been raised several feet and if allowed to drop back might crush someone.

He said he always wondered when he received the signal if he would be able to get the men to the surface without the hoist going to pieces.

This hoist was what might be called a "first motion" or direct hoist as the drum shaft was direct connected to the engine crankshaft, the engine was not reversible, but the drum was free to revolve on its shaft. For the benefit of readers in California and particularly Nevada County, I might say that if they wish to look at this hoist, as a matter of curiosity, it is located about half way between Grass Valley and the little mining camp of Rough & Ready, on the right-hand side of the trail.

J. H. Stretton.

Los Angeles, Calif.

QUESTIONS BEFORE THE HOUSE

Removing Scale from Piping

Perhaps the method I have used to remove scale from oil-cooling coils and cooling jackets may be of interest to Mr. Hyde who asks for suggestions in the May 13 issue. The coils had become inefficient and a solution of one-half muriatic acid and one-half water was poured into each coil. It took several gallons. The coils being made of copper, the solution was left in the coil only two hours, and was then washed out with clean water. Two applications restored the coils to their original efficiency.

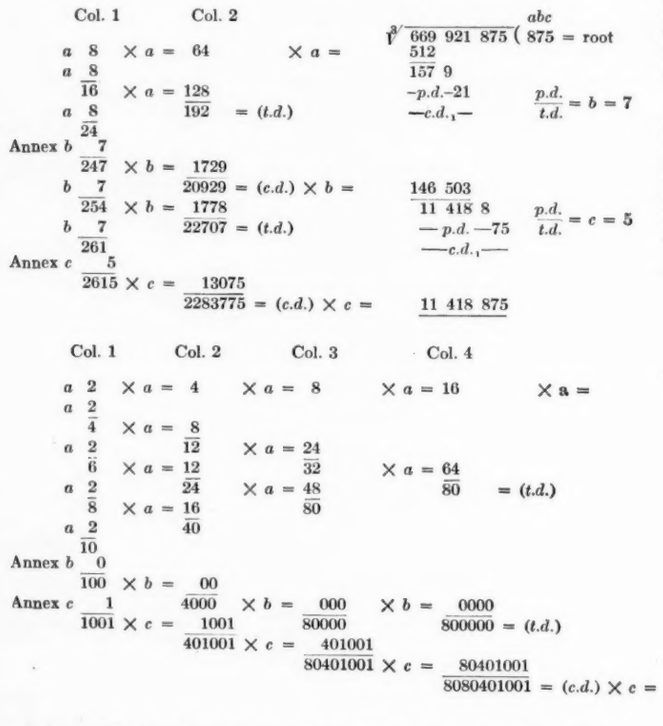
A solution of the same strength was applied to the jacket of a large dry-air pump with equally good results, the solution in this case being left in the jacket for a period of six hours.

JOHN F. HURST.

Louisville, Ky.

Horner Method of Extracting Roots

It occurred to me while going through the cube-root lesson in the Engineers' Study Course that it would be of interest to show how roots may be extracted by the Horner method given below.



In general, the given number is divided into periods (starting from the decimal point) each containing as many figures as there are units in the exponent.

At the left of the number, columns are arranged one less in number than the exponent. They may be numbered 1, 2, ... $(n - 1)$, from left to right. The first figure in the root (a) is found as usual, and its first power (a^1) is written at the top at col. 1; its second power (a^2) in col. 2, etc.; so that its n^{th} power (when exponent $= n$) is written under the first period. Subtract and bring down the next period for the new dividend. Go back to col. 1, add a^1 to a^1, multiply the sum by a, add the product to a^2 in col. 2; multiply the sum by a and carry to the next col., stopping at the last col. or col. $(n - 1)$. This sum is the trial divisor $(t.d.)$, the third number in column 2.

Repeat this process, stopping each time one column to the left, until the sum falls in the first column. This sum will be (an).

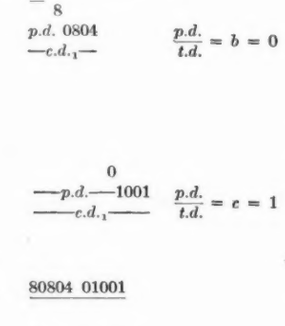
The partial dividend $(p.d.)$ is the remainder, with the first figure only of the annexed period. Then

$$\frac{p.d.}{t.d.} = b = \textit{second figure in the root}$$

The complete divisor $(c.d.)$ is found by annexing b to the sum in col. 1, one place to the right, multiplying this by b and adding the product to the sum in col. 2, two places to the right, multiplying this sum by b and adding to the sum in col. 3, three places to the right, etc., until it stops in the last column $(n - 1)$ places to the right. This sum is the complete divisor $(c.d.)$. Multiply it by b and subtract it from the complete dividend $(c.d.)$.

These processes for finding the trial and complete divisors are repeated until the root is found, or found to as many decimal places as desired. The last figure written in the root at any one time is the only figure used for adding and multiplying, so that multiplying from one column to another is done without the necessity of setting down the figures.

When finding imperfect roots, one less decimal than those already found can be obtained by partial division. For each decimal so obtained cross out $(n - 1)$ figures from the right end of the last complete divisor, and $(n - 2)$ figures from the last remainder, using these for divisor and dividend respectively. This is true for any method. The Horner method is easily learned and very convenient to use.



PORTER STAFFORD.

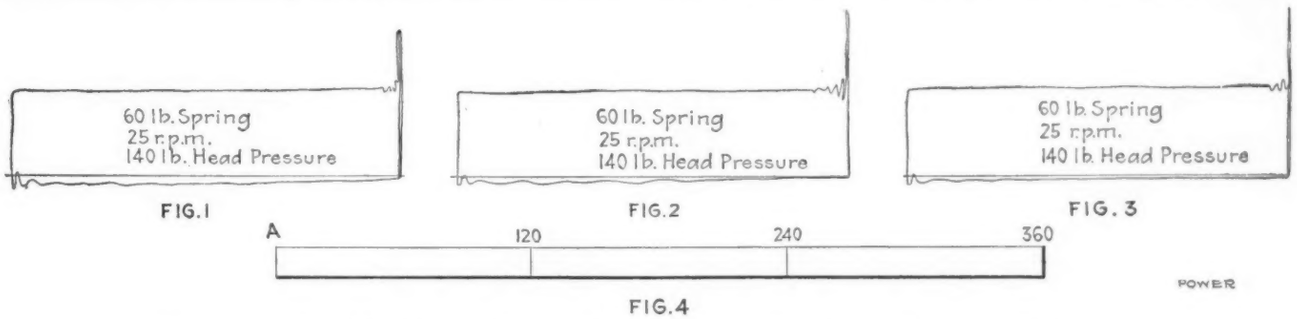
Erie, Penn.

Pumping-Engine Water-End Diagrams

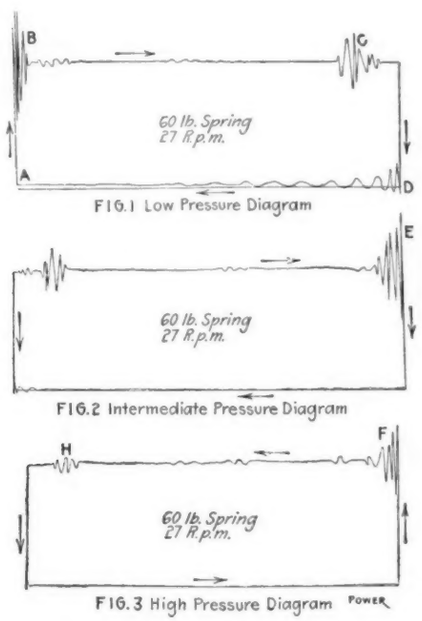
Recently I took the accompanying diagrams (set No. 1) and in looking through back numbers of POWER for diagrams for comparison came across those shown by John Burnes in the Oct. 15 issue, and here referred to as set

No. 2. Set No. 1 was taken from the water end of a vertical, triple-expansion pumping engine 24, 46, 70 and 34 by 60 in., designed to pump 25,000,000 gal. every 24 hr. against a head of 140 ft. at 25 r.p.m. The diagrams submitted by Mr. Burnes, or set No. 2, were taken from a vertical triple-expansion, pumping engine, 28, 54 and 80 by 60 in. with a capacity of 20,000,000 gal.

In comparing them I can find but two points in common, that is, the great increase of pressure at the commencement of the discharge stroke, and the few waves or



Diagrams (Set No. 1) from Water End of Triple-Expansion Pumping Engine



Diagrams (Set No. 2) from Water End of Large Pump

pressure fluctuations at the beginning of the suction stroke.

Mr. Burnes thinks that the great excess of pressure over the actual pressure in the water main, as shown in his diagrams, to be due to the inertia of the valves. The pressure was due to inertia offered by the water, pump valves, valve springs and the indicator spring.

It is noticeable that, even though the excess pressure is higher in the case of set No. 1 than it is in set No. 2, the accordion effect is not nearly so pronounced. I think a remedy could be found for this in carrying plenty of air in both the discharge- and suction-air chambers. During the time of taking set No. 1 water was not allowed to rise more than 6 in. from the bottom of the gage-glass, and the bottom of this glass is about 8 in. from where the air chamber tapers to enter the discharge main.

Due to the incompressibility of water (0.000040 to 0.000051 for one atmosphere, decreasing with increase of temperature. Kent, page 551), any deviation from a uniform discharge pressure must work to the detriment of those parts that resist the shock, thereby necessitating more frequent keying up and more careful attention to all bolted connections intermediate to the steam system and pump pressure.

The wavy lines at the commencement of the suction stroke, I believe to be less preventable in the case of set No. 1 than in set No. 2, although the pump, through a 42-in. suction takes water from a well supplied by a 9-ft. tunnel, there is not the facility for keeping the suction head from varying as in set No. 2.

The irregularity near the end of the discharge line I never saw on a pump before, and do not know the cause unless it could be insufficient air chamber capacity. I could just as readily tell at what per cent. of stroke cutoff takes place by carefully watching the valve positions as I could tell the relative position of any two cylinders in passing a given point. Mr. Burnes' analyses of this cause may be correct, but his method does not carry conviction. The following method of determining this point could, no doubt, be improved upon, but I believe for practical purposes it is sufficiently accurate.

The length of the diagram represents diagrammatically the length of stroke or one-half a revolution, twice the length of diagram is, therefore, a total revolution, and as in this case the engine is a cross-compound with three cranks set at 120 deg. apart, each crank will pass a given point 120 deg. ahead of the following one. By taking a narrow strip of paper, Fig. 4, twice as long as the mean length of the indicator diagram a close approximation of a complete revolution is obtained. Consider this Fig. 4 as representing 360 deg. and point *A* as the commencement of the stroke of any one cylinder, the position of the other two cylinders will be

$$\tfrac{120}{360} \text{ and } \tfrac{240}{360}$$

of the total length of the strip measured from point *A*.

Starting with the high-pressure diagram, place point *A* of the strip on the line on the card indicating the commencement of the discharge stroke, and by repeating the same operation for the intermediate pressure and the low-pressure cylinders against the lines marked 120 and 240 deg., the points where these diagrams or one part of the stroke overlaps the other is readily determined.

Chicago, Ill. James W. Beatty.

[Crosshead and crank travel are not constantly proportional. At one-third of a revolution the piston would not cover exactly two-thirds of its stroke.—Editor.]

INQUIRIES OF GENERAL INTEREST

Size of Safety Valve—Does a boiler carrying 100 lb. pressure require a larger safety valve than one carrying 25 lb.?

F. M.

No, not so large, other things being equal. According to the best modern authorities, the area of a safety valve should be proportioned directly as the amount of water evaporated by the boiler and inversely as the pressure which the boiler is to carry.

Jam Nuts—When two nuts are used on a bolt, one a jam nut or lock nut for the other, if one nut is thicker than the other, which should be put on the bolt first.

H. S. C.

The thick nut should be put on first, for, having more threads, it can be drawn up tighter with less danger of stripping the threads, and on account of its greater thickness it can be easier held by a wrench while the outside nut is turned.

Cleaning Smoky Burette—What will clean a dark, smoky deposit from a gas-analysis burette?

J. W. D.

If the burette is discolored with an oily deposit it can be cleaned with gasoline; if discolored with a deposit of carbon, kerosene should remove the smoky appearance. If the glass has been discolored while hot, it may be difficult to remove the stain without soaking the glassware in the cleansing liquid for some time, occasionally scrubbing it with clean cotton waste.

Connecting Exhaust Injector—What is the best way to connect an exhaust injector to a boiler?

P. W.

Take the steam out of the upper side of the engine exhaust pipe at a point where it will be as dry as possible and as little reduced in pressure below that at which it was discharged from the engine as possible. The connection should nevertheless not be too near the engine because the pipe between should be long enough to act as a receiver so that the injector supply may be fairly steady. The connections of the injector suction pipe and the discharge to the boiler should be as direct as possible, with few ells and bends, and the connection to the boiler should contain a check and a stop valve.

Piston Clearance—How may the piston clearance at each end of a cylinder be determined?

R. J. B.

The engine is put on center at each end of its stroke and a mark made on the guides registering with a mark on the crosshead. The connecting-rod is then disconnected from the crank and the piston moved as far as it will go each way, i.e., until it strikes the heads. Marks are then made on the guides registering with the first mark on the crosshead. The distances between the two marks on the guides at each end of the crosshead travel show the linear piston clearance at the corresponding cylinder ends. If the volume of clearance is desired the piston is moved first to one end, then the other of its stroke, and the measured amount of water required to fill the clearance space back to the valve seat shows the clearance volume, and whether or not it is equal at each end of the stroke.

Stay-bolt Sizes—How does one determine the size of stay-bolt required for a given pressure and pitch?

O.. W.

If the pitch of the stay-bolts is s, in inches, the area supported by each stay-bolt is $s \times s$ and the pressure $P = s \times s \times p$, where p is the pressure in pounds per square inch. Knowing the total pressure P on each stay-bolt the required area of cross-section is P divided by the allowable load per square inch on the stay-bolt. The threaded part of the bolt must have a cross-sectional area at the root of the thread not less than the above. From this area, a, the diameter of the required bolt d is found from the formula

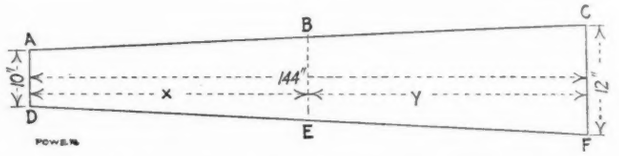
$$d = \sqrt{\frac{a}{0.7854}}$$

If the bolt has 12 threads to the inch the diameter over the outside of the thread should be

$$D = d + 0.1443,$$

according to the Massachusetts boiler rules. By the same rules the allowable load per square inch on wrought-iron or mild-steel stay-bolts up to and including 1¼-in. is 6500 lb., and for larger bolts 7000 lb.

Halving Trapezoidal Area—In a trapezoidal figure, dimensioned as in the diagram, where should a perpendicular



line BE be drawn so that the areas ABEDA and BCFEB will be equal?

C. J. B.

The area of a trapezoid is equal to half the product of the sum of the bases by the altitude or in this case

$$\frac{(10 + 12) \times 144}{2} = 1584 \text{ sq.in.}$$

is the area of the whole figure.

Let

x = Altitude of trapezoid ABEDA
y = Altitude of trapezoid BCFEB

AD is given as 10 in.
CF as 12 in.
Let BE = a.
Then the area of the trapezoid ABEDA is

$$\frac{(10 + a)x}{2}$$

and, by the conditions is to be equal to the trapezoid BCFEB, or

$$\frac{(10 + a)x}{2} = \frac{(12 + a)y}{2} \quad (1)$$

Since both together equal the area of the entire figure, 1584 sq.in.,

$$\frac{(10 + a)x}{2} + \frac{(12 + a)y}{2} = 1584 \quad (2)$$

It is also known that

$$x + y = 144 \quad (3)$$

With the three equations (1), (2) and (3) the three unknown quantities can be determined, but in this case only x and y are needed so a may be eliminated.

Equation (1) reduces to

$$(10 + a)x = (12 + a)y$$

$$a = \frac{10x - 12y}{y - x} \quad (4)$$

Equation (2) reduces to

$$(10 + a)x + (12 + a)y = 3168$$

$$a = \frac{3168 - 10x - 12y}{x + y} \quad (5)$$

Equating (4) and (5)

$$\frac{10x - 12y}{y - x} = \frac{3168 - 10x - 12y}{x + y}$$

$$(10x - 12y)(x + y) = (y - x)(3168 - 10x - 12y)$$

$$3168y + 4xy = 3168x \quad (6)$$

$$y = \frac{3168x}{3168 + 4x}$$

From equation (3)

$$y = 144 - x$$

Then

$$\frac{3168x}{3168 + 4x} = 144 - x$$

which reduces to

$$x^2 + 1440x = 114{,}048$$

Completing the square

$$x^2 + 1440x + (720)^2 = 114{,}048 + (720)^2 = 632{,}448$$

$$x + 720 = \sqrt{632{,}448} = 795.266$$

$$x = 75.266 \text{ in.}$$

and from equation (3)

$$y = 144 - 75.266 = 68.734 \text{ in.}$$

ENGINEERS' STUDY COURSE

Making a Flue-Gas Analysis—Part II

Unpacking and Assembling Apparatus

The Orsat apparatus is shipped knocked-down; that is, the glass parts are taken out of position and securely packed so as to avoid breakage. The first thing to do, then, is to get the apparatus properly put together again.

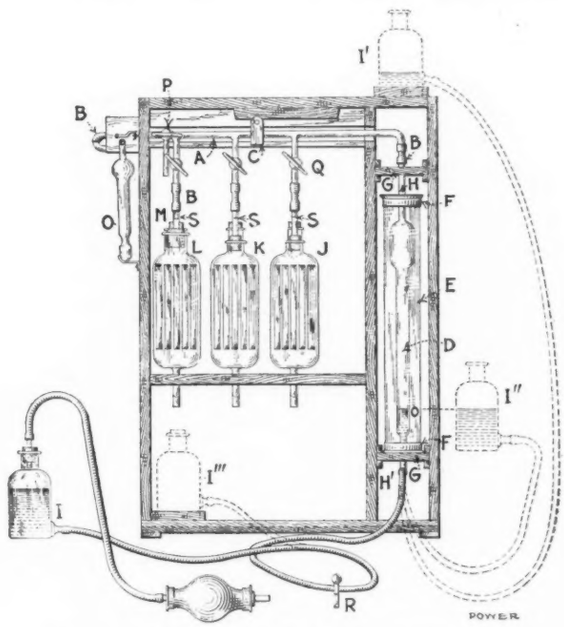


Fig. 1. Diagram for Assembling Orsat

If you purchase an Orsat-Muencke, the following directions will serve as an exact guide. If you happen to purchase some other type these directions may have to be modified slightly, but the modifications will be self-evident when you come to examine the parts. The directions I will give for preparing the chemicals and operating the apparatus can be followed exactly with any of the standard types of Orsat.

After carefully unpacking the box in which the apparatus is shipped and making sure that you have not missed anything, dust off the cabinet and wash the glass parts with warm water and soap, rinsing thoroughly in clean water at the end. Take both front and back slides out of the cabinet and place it before you so that the long, narrow compartment is at the right.

Next, put the header *A*, Fig. 1, in position, first making sure that the five rubber connectors *B* are in place ready to make the connection between the header and the other parts. The header is held in place by the small wooden latch *C;* be sure that this is in the closed position before proceeding.

The next step is to fit the burette or measuring chamber *D* into position. This burette is provided with an outer case *E*, of glass, for the purpose of preventing error due to change in the temperature of the air in the room affecting the gas in the burette. The space between the outside case and the burette should be filled with clean water. As the rubber corks *F* both contain vent holes, the one in the bottom cork will have to be plugged up after the water is run in. See that the white side of the case with the blue stripe down the middle comes on the side opposite to the scale marks on the burette. This white and blue background makes it easier to read the water level in the burette when measuring.

Having the casing filled with water, the next step is to connect the burette with the header at the top. Put the two small sliding shelves *G* over the stems *H* and *H'* and fit the shelves into their grooves. This will hold the burette in position so that you can use both hands for slipping the rubber connector over the stem. Be sure that the stem is moistened with water as this will make the rubber slide much more easily. Draw the top shelf out a little so

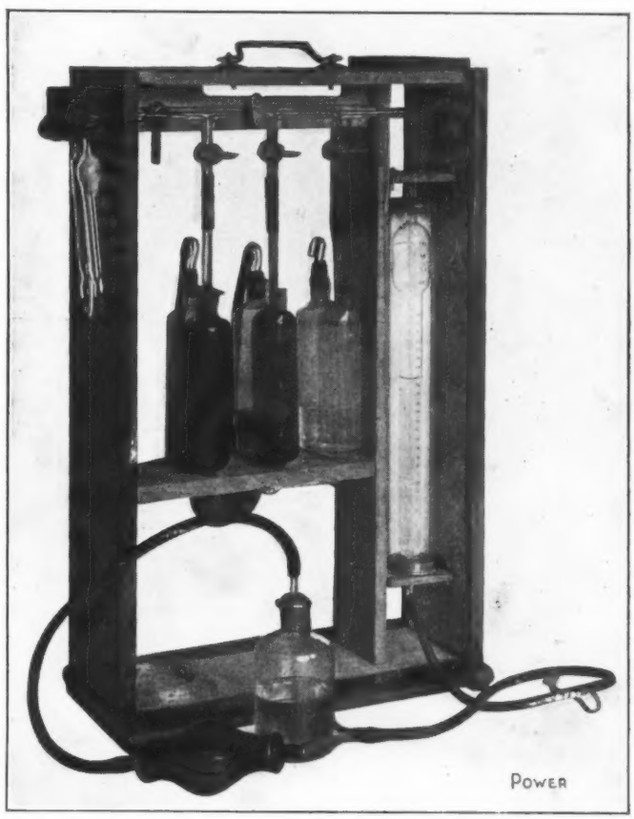


Fig. 2. Front View of Assembled Apparatus

that the stem does not come directly under the header end, then gently work the rubber connector over the stem until it fits snugly with the weight of the burette resting on the bottom shelf. This will keep strain off the header. Great care will be necessary in the making of these connections as the use of too much force will result in breakage.

Two pieces of rubber tubing come with the apparatus. The longer piece is for making the connection between

the burette and the leveling bottle *I*. Before making this connection, slip one of the pinch cocks on the tubing, as this will come in handy to regulate the water level when making analyses.

Next, the pipettes *J*, *K* and *L* are put into place. These pipettes consist of two bottle-like parts connected at the bottom by means of a glass neck. The construction of the pipettes varies somewhat with different apparatus. Some, such as *J* and *K*, have the stem *M* connected solidly to the bottle part while with others, such as *L*, the stem forms part of a stopper which makes a ground-glass fit with the neck of the bottle part.

A number of small glass tubes are furnished to insert in the front leg of each pipette. These tubes may come

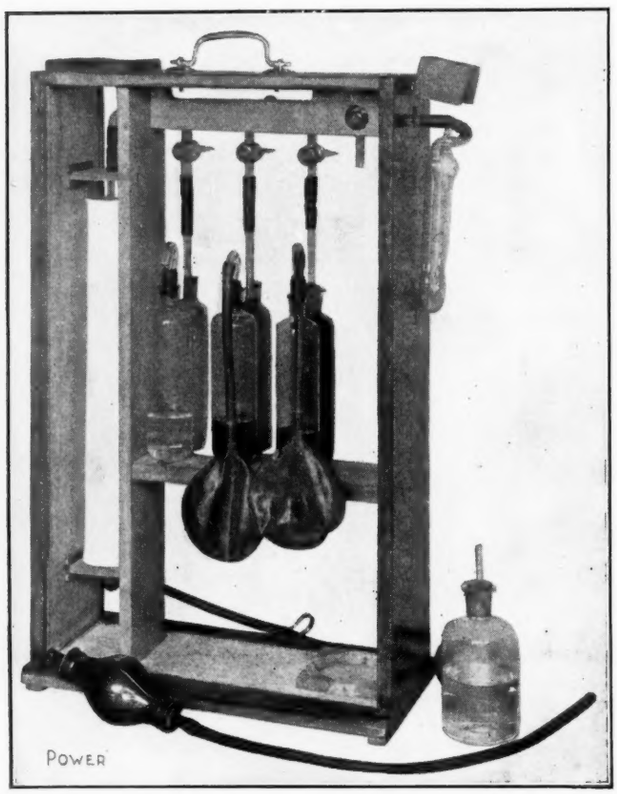


FIG. 3. REAR VIEW OF ASSEMBLED APPARATUS

already in place. If so, there may be some cotton wedged into the bottle above them to prevent them rattling and possibly becoming broken in shipment. This cotton must all be removed. If the tubes do not arrive already in place fill the front leg of two pipettes as full as you can with the plain tubes and the front leg of the third pipette with the tubes which have little spirals of copper wire in them. Be sure that the pipettes are arranged in the cabinet in the proper order; the two nearest to the burette should contain the plain glass tubes while the farthest one should contain the tubes with the copper spirals. In time these copper spirals will become dissolved by the solution used in this pipette and new tubes containing spirals will have to be purchased and put in.

Into the back leg of each pipette fit a goose-neck stopper, as shown in Fig. 2, and to the goose-necks of the two pipettes furthest away from the burette attach the rubber gas bags, as shown in Fig. 3. The object of these bags is to prevent air from coming in contact with the chemicals in the pipettes and spoiling them. The chemical in the first pipette need not be so protected.

The U-tube *O*, Fig. 1, is next attached to the end of the header, as shown, and the apparatus is ready to load and use. This U-tube has a wad of mineral wool in its open end and serves as a filter for the gases before they enter the apparatus, catching any particles of dust and soot which might otherwise foul up the header and cause trouble in the glass cocks. It also can be filled with small lumps of calcium chloride for absorbing moisture from the gases. This, however, is not absolutely necessary.

I would advise all beginners to practice loading and manipulating the apparatus with plain water before putting in the chemicals, as the latter are nasty to spill or slop around as well as somewhat too expensive to deliberately waste. So, until you fully understand how the analysis is conducted, plain water is the safest and cheapest material to experiment with.

Analyzing Boiler Tests*

BY A. BEMENT

One of the features of difficulty which interposes itself in the analysis of a boiler test is the correct measurement of the temperature of the escaping gases. As a rule, it is necessary to calculate a heat balance before any analysis of results can be attempted. This requires a knowledge of the temperature at which the gases leave the boiler and correct measurement is really very difficult. This will surprise most people, as it is generally felt that such measurement is very simple. The difficulty of this measurement has two phases, one has reference to the location of the measuring instrument, the other to the heat conducted away by the instrument and by the walls of the flue in which the instrument is located.

Assuming a uniform air supply as existed in the Detroit Edison tests, it necessarily follows that the volume of the gases is in direct proportion to the coal burned, and the large capacities were obtained with the large coal consumption. Therefore, the high rates of evaporation were accompanied by large gas volume and the low rates by small volume. In each condition, however, the flue area and gas passage being the same, the natural result is that the flowing gas volume, seeking the path of least resistance, would not fill the flue in the case of the small volume of gas; or, in other words, the center of the gas volume would not be the same in all cases.

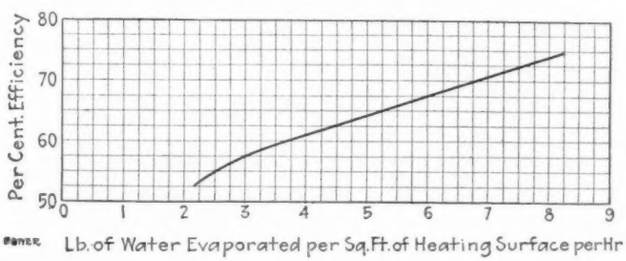
The location of the measuring instrument with reference to the *flue* remains constant, but with reference to the *flowing gas body*, it is not constant. For this reason the gases come in contact with the measuring instrument to a greater or less extent, depending on the amount of the gas flowing. The prevailing tendency of this condition is to cause the temperature to appear too low with small capacities and too high with large ones. It is apparent that the quantity of the heat radiated from the flue and from the measuring instrument is approximately constant, because the area of the instrument and of the flue are constant for all conditions. The quantity of the gas flowing through the flue is, however, a decided variable, it may be three or four times greater at high than at low capacity. The quantity of heat lost at high capac-

*Supplementary to "Steam Boiler Efficiency," by same author in the preceding issue.

ity is a comparatively small percentage, and the quantity lost at low capacity is a large percentage, the result is that the heat lost in hot gases at high capacity appears higher, and at low capacity lower than it should. In this way we are probably caused to consider chimney losses to be greater than they are at high capacity and less at low. This being true, we have another reason for assuming a constant efficiency, as illustrated in the diagram in last week's issue.

The foregoing discussion has reference to those cases where the data is derived from a heat balance, wherein the above mentioned cause, and that of incomplete combustion by escaping hydrocarbons are generally important and unknown variables, both of which make the loss at high capacity appear higher than it is. Therefore, if we could take direct results from tests without the intervention of a heat balance, we would eliminate some of the difficulties of dealing with it. It would, however, be necessary to have complete combustion, a uniform loss of fuel in the ashes and a constant air supply, all of which are hard to obtain in usual practice.

In looking over his data for a case that might be of service, the author finds the performance shown in the curve herewith, which comes nearer, from a theoretical



standpoint, to meeting these requirements than any other extensive series of tests that he has. These tests, some 60 in number, were all run on one of the boilers of an important power plant, and the efficiency shown is derived directly from the evaporation, without any correction for fuel lost in the ashes or anything else. While the points are not shown in the diagram, the location of the curve is copied from the original record, and so its accuracy may be depended upon. This diagram shows the efficiency as ranging from 52 per cent. at 2.1 lb. evaporation, to 75 per cent. at an evaporation of 8.25 lb. per sq.ft., a difference in efficiency of 23 per cent. The coal used was of a variable quality, which had something to do with the result.

It is possible to account for 12 per cent. of this lower efficiency by the higher ash content of the coal that was used in the low efficiency tests. This leaves a difference unaccounted for of 11 per cent. and it would be necessary to assume that this was due to unfavorable size of coal, to bring the result down to a constant efficiency for the full range of capacity shown by the diagram.

Thus it appears when an effort is made to analyze even such elaborate data as these, we are confronted with a difficulty, not in being unable to boost the efficiency at high capacity, but in finding a justification for bringing the efficiency of the low capacity up to it. At all events when large coal users obtain results shown in the diagram, they are disposed, not only to be satisfied, but to feel that it might be a good thing if the Bureau of Mines would spend some more money for additional study.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Marcel G. Brindejonc des Moulinais flew 674 miles in 7 hr. 4 min. Any aviator who can hoist the name alone is some derrick. It's long enough for a tail to a kite.

⁂

"A college education is worth $25,000 in increased earning capacity," declares a Western university. It is, and it isn't. There are college men who could not earn this sum in 25 years; there are men earning twice as much in a year who never even walked by a college. It's a fine thing to have, but its earning capacity depends upon the practical use made of it.

⁂

Some tall and towering things have been served to you in "Power," and if you turn back to page 884 you'll see that we are still soaring. This time it's the Woolworth Building power plant—910 ft. from bed rock, suh; meaning the building. It takes miles of things to operate this plant, and Thomas Wilson has it all in the story. And a "5- and 10-cent" idea made this beautiful building possible.

⁂

Arrested for non-support, a New York man testified that he gave his wife a dollar the other day to buy food. "When she returned, she had an onion, a bunch of radishes, and a jag!" said he. While the return shows a rather low load for the eats, the peak stands right up on its hind legs. And all for a dollar!

⁂

Our newest "contemporary" is the "Hobo News." As somebody has to work to get this paper out, isn't this heresy and schism in the minds of the craft? Any advertising in the "News"? Canned goods and soaps might make a hit.

⁂

The "code" microbe is gnawing the vitals of some of the professional engineers. They must have a code to define what's what and who's who. After wading through a column of this stuff we come to the conclusion that the dope is a reiteration of "Be honest, and don't slam the other fellow." Good gosh! You and I learned this back in the little old red schoolhouse days—and the most of it still sticks, doesn't it? Bimeby, people will become suspicious if a learned society thinks it necessary to make a publicity campaign on honesty alone.

⁂

Our cartoon this week sure shows the situation in some power plants. When things are slipping along to the satisfaction of Mister Boss, the engineer who wants to disturb his complacency with a suggestion is about knee-high to a peanut. When the motive power lays down and refuses to mote, it's Mister Engineer who looms large in the picture.

⁂

You should be exceeding glad that the advertising men are going to yank the "crook" out of crooked and put a capital H on Honesty. And their recent convention in Baltimore gave added impetus to this campaign. How will it benefit you? This way: Your Helen won't buy a sealskin sacque and have the village chemist analyze it as "cat;" you won't pay $1.15 for your $2.50 negligee shirt, and find it was marked down from 59 cents; your wool duds won't turn out to be just shoddy: your genuine Panama lid won't be grown in Connecticut; the impure fooders and the expired patent mediciners won't— There's going to be better times when these ad men further exploit the Truth and put a crimp in the fakers.

⁂

This column is being written on Friday, June 13, 1913, but we've packed our rabbit's foot and crossed our fingers, so why should we worry and raise a wrinkle? We'd even accept a raise of thirteen silver dollars if we thought the Old Man would try to hoodoo us that way.

Saturday, June 14—Nothing happened, none of it.

⁂

Today, being Flag Day, every lovely girl and every mere male editor on the staff wears Old Glory on his or her manly or otherwise bosom. Even the dude editor's cane is doing duty as a flagstaff. The Stars and Stripes should wave over every power plant in the land. How about yours?

Stewart's Experiments on Indicators

By Julian C. Smallwood

SYNOPSIS—The author points out that variation of friction for different springs has not been sufficiently proved; that for precise calibration the temperature, speed and other conditions present should be more nearly identical with those which obtain in practice; and proposes more correct methods of calibration.

The paper presented by James G. Stewart before the Institution of Mechanical Engineers, a review of which appeared in the June 17 issue of Power, page 851, is a valuable contribution to indicator science and practice. It would seem, however, that the results of the variation of friction with spring stiffness are not sufficiently proved. If Mr. Stewart's reasoning is correct, that it is caused by an imperfect cylinder or cylinder cap, it would have been less or nil with a truer instrument. It is unfortunate that other sets of results covering this point were not presented.

Fig. 1. Indicator Spring Calibration Curves

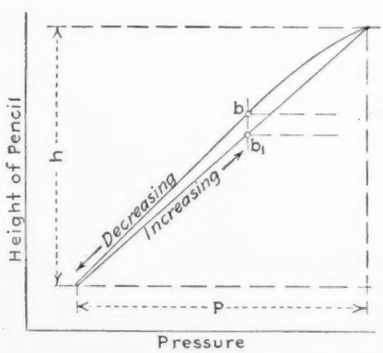


Fig. 2. Calibration Curves for Correcting Fig. 3

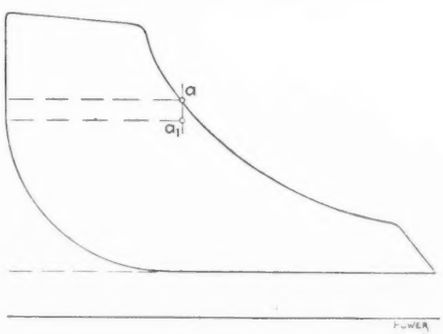


Fig. 3. Indicator Diagram

All the tests were made with compressed air as the pressure medium, so that the conditions of temperature and working fluid do not apply to the general case. This will cause a difference between the errors experimentally found and those in usual operation, but it is likely that, in the latter case, they will not be any less.

It does not seem to be entirely proved that the friction is independent of speed, as Mr. Stewart assumes, or that it is constant for a given set of oscillations. Nevertheless, the results as a whole must be considered trustworthy, and that, therefore, past experimenters have not appreciated the magnitude of the errors discussed.

The present writer has been working toward Mr. Stewart's ends, though by different methods, for some time past, with a view to the construction of an accurate method of correcting indicator-pencil motion, being led to do so by the following considerations: The usual calibration is accomplished by a more or less jerky variation of motion and pressure. This does not duplicate the actual condition of pencil friction or of pencil motion, which latter might, so the present writer considered, easily affect the friction. Further, when the observations of such a test are plotted, two unconnected curves result, as Fig. 1; whereas, in actual operation, the relation between pressure and height is a continuous one, with no unfilled gaps at the ends. Certain researches along kindred lines indicated that the decreasing relation may not be represented by a straight line, but by a curve, as shown in Fig. 2, joined at the ends to the line for increasing values. This applies to any instrument of precision depending upon springs, and, probably, to all indicating instruments. That is, if an instrument, such as an indicator, is true for increasing values, it must be untrue for decreasing values. This phenomenon is due not only to friction of bearing surfaces, but to internal friction of the spring itself, the effect being similar to hysteresis in magnetism. From the present writer's experiments, it appears likely that the relation between the force on a spring and its deformation is different for different ranges of force, and that friction is less, regardless of the absolute pressure, the less is the range, a point which seems to have escaped Mr. Stewart's attention.

It appears, then, that to calibrate an indicator spring with precision, it should be tested under a gradually rising and falling pressure, such as actually obtains in a steam or gas engine, the limits of the pressure being the same as those of the indicator diagram to which the results are to be applied. The problem presented was to design a steam container equipped with a valve or valves to accomplish this variation, and with an apparatus for obtaining an autographic diagram, such as Fig. 2. The test gage for measuring the true pressure must itself be sufficiently free from friction to give substantially true decreasing readings.

An attempt was made to satisfy these conditions as follows: A recording-pressure gage having a pressure tube of the helical type with pen arm directly attached was found to have very little friction, and so was used to measure the true pressure. The clockwork was detached from the dial, and a small wooden drum placed on the dial spindle instead. The gage and the indicator to be tested were both connected to the pressure chamber in which it was attempted to vary the pressure by hand manipulation of valves. One cord was passed around the indicator drum and another around the drum on the gage-dial spindle, so that when the cords were pulled together, the dial and the drum would have similar motions. By comparing the corresponding records of height of pencil on the indicator card and true pressure on the gage blank, data for a curve similar to Fig. 2 could be ob-

tained. The apparatus has not yet been developed enough to yield satisfactory results. The method is inferior to Mr. Stewart's in that error is introduced because of elastic hysteresis of the pressure gage.

With such a diagram as Fig. 2, the indicator diagram could be readily corrected as follows: The two diagrams are laid side by side, as shown by Figs. 2 and 3. The true scale for ascending values on the indicator diagram (that is, values on the compression line) is given by P and h. To represent the point a, Fig. 3, on this scale, the construction $abb'a'$ is used, the point a' being the required corrected position of a. Enough points are thus corrected to determine a corrected expansion line. The ascending spring scale will then apply correctly to the whole diagram. This method appears to be less laborious than Mr. Stewart's, and, because the calibration is affected by the *range* of pressure, more accurate.

Returning to Mr. Stewart's paper, his results on the drum-motion investigation call for little comment, in that, experimentally, they only brushed the surface of the subject. His method was the one used by Mr. Brightmore, namely, getting a number of correct positions of the drum by an electric spark at the pencil point, made by commutator contacts on an engine crosshead driving the indicator. Apparently he obtained results on only a single set of conditions. Strictly speaking, the errors in the drum motion shown by his curves are not effective errors as was shown by the present writer in an article on "Distortion of Indicator Drum Motion," in the Aug. 20, 1912, issue of POWER. The effects of friction of the drum spindle and of guide pulleys, also given in this publication, have not been touched upon at all, and these are by far the most likely and largest sources of error in drum motion.

It is interesting to note, in closing, that, whereas the effect of friction in the pencil motion is to make the indicator diagram larger, on the drum motion it is to make it smaller, and these two errors often counterbalance sufficiently to give reasonable results. The net effect is to make the usual indicator fairly reliable as an instrument to measure mean effective pressure, but for other uses its design may be much improved.

❋

Bursting Flywheel Causes Two Deaths

SYNOPSIS—A flywheel explodes, bursting two main steam pipes, causing the death of an oiler and the engineer.

❋

The engine room of the Alpha Portland Cement Co. was the scene of a fatal flywheel accident at 2 a.m., Monday, June 9, resulting in the death of two men, both employed in the engine room.

The engine room contained three cross-compound main power units and a turbine-lighting set. The three main engines were each fitted with a sheave flywheel used to drive as many line shafts by the English system of rope drive, i.e., each rope independent of the other.

Two of the line shafts ran across the end of the engine room, as shown in Fig. 1. The engine at the right was rope connected to a third countershaft, as shown at the

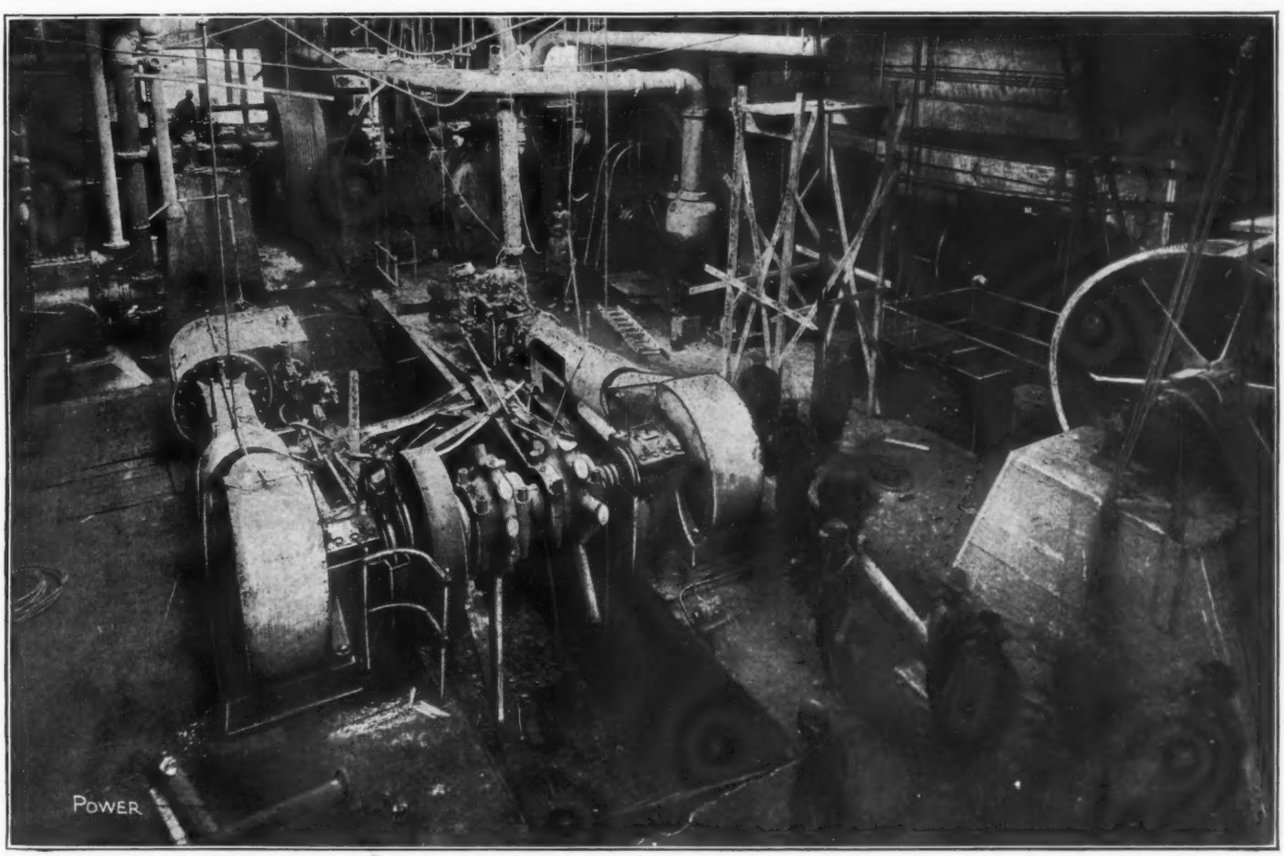


FIG. 1. VIEW OF THE WRECKED ENGINE FROM THE CRANK END

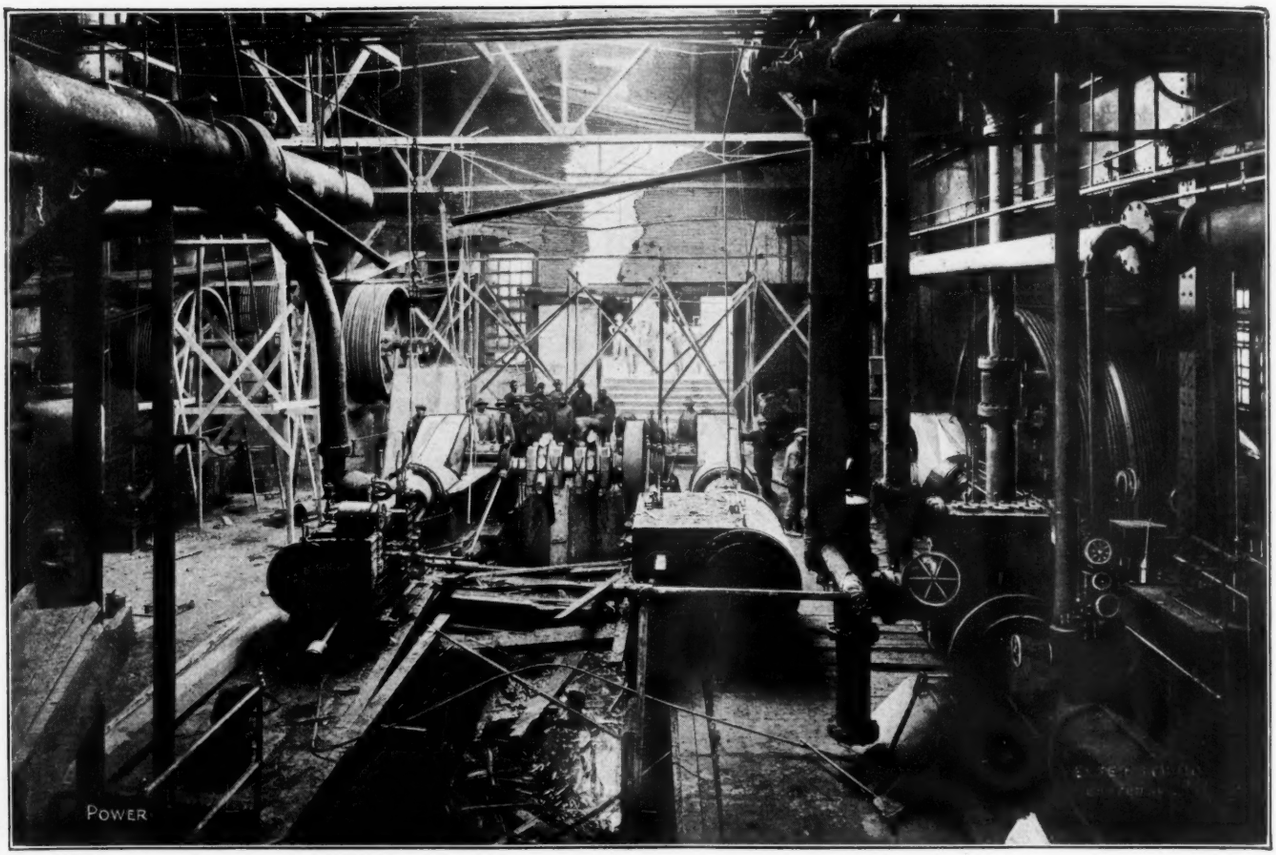


FIG. 2. SHOWING ENGINE AND DAMAGED WALL CAUSED BY FLYWHEEL EXPLOSION

left of Fig. 2. The engine at the right of Fig. 2 drove the first shaft, shown in Fig. 1, which also carried an idle sheave wheel in line with the right-hand half of the flywheel of the wrecked engine. The second line shaft, at the rear of the first, was rope driven from the other half of the flywheel.

This flywheel was in reality two sheave wheels made in half sections with split hubs, each held together by four 2-in. bolts, Fig. 1. The rim joints of each wheel section were secured with five 1¾-in. bolts. The adjoining edges of the wheel rims were flanged and the two sections, thus bolted together, formed the flywheel as a whole. It was 18 ft. in diameter, with a 70-in. face, which was made with 26 grooves, and ran at a normal speed of 90 r.p.m.

Both the flywheel and driven sheave wheel were demolished while the idle sheave wheel on the front line shaft was found whole, with the exception of a small piece that had been broken out of the edge of the rim. When the flywheel burst a 7- and a 9-in. steam main were broken and the steam from 3000 hp. in boiler capacity escaped, filling the engine room with live steam, which, from all indications, was the cause of the death of Herbert Buskirk, engineer, and Edward J. Butler, oiler. Engineer Buskirk was found lying at the edge of the wheel pit shown in the foreground of Fig. 1; Butler was found next to the wall at the right between the cylinders of the engine and the line shaft. He was dead and had evidently been scalded to death. The engineer was alive, but died in the hospital five hours later.

FIG. 3. FRAGMENTS OF EXPLODED FLYWHEEL AND PIECES OF PIPING

Just what occurred at the time of the accident is not known. From conversation with the officials and men about the plant, it appears that the oiler who fortunately escaped had, in the performance of his duties, just felt of the low-pressure crank of the wrecked engine, which was between the other two units, and had gone toward a side door. Everything about the engine room appeared to be as usual and no trouble had been experienced during the run. The first indication of danger was a crash. It is assumed that the engineer attempted to shut down the wrecked engine, as he was last seen at the throttle which was later found closed. The engine ran condensing and had 22 and 38 by 48-in. cylinders. It was equipped with an automatic safety stop and whether it or the engineer closed the throttle is not known. There is no evidence to show that the engine speeded up prior to the accident, and so far as could be determined from an examination, the governor, which was of the shaft type, was in good order.

Although the flywheel was broken into very small pieces, Fig. 3, it is not evident that it failed first. It will be noted that the sheave wheel on the line shaft was also demolished while the one on the shaft in front of it was but slightly damaged. This fact would indicate, as a probable cause for the accident, that the driven wheel failed first with the possibility, and even probability that the entangled ropes on the engine flywheel caused an initial fracture of the rim or spokes, resulting in a flywheel explosion from centrifugal force, although running at normal speed.

Most of the damage to the engine room was confined to the wrecked engine, the walls in line with the flywheel and to the roof above. But four pieces of the flywheel found after the accident were of large size. Two pieces were hurled through a 10-in. brick wall, over a store house, landing in a field. Each was about 30 in. long. Another large section, approximately 6 ft. long, passed through the roof, and landed on a spur track, severing a rail as if it had been a piece of chalk. The rest of the wheel was found scattered about the premises in very small pieces.

The flywheel was insured by the Hartford Steam Boiler Inspection & Insurance Co., which will stand the loss occasioned by the accident.

National Electric Light Convention

The thirty-sixth convention of the National Electric Light Association was held in El Medinah Temple, Chicago, on June 2 to 6, inclusive. About 2000 delegates and guests were registered. President Frank M. Tait called the first general session to order at 10:30 a.m., Tuesday, and introduced the Hon. Lawrence E. McGann who welcomed the visitors to the city on behalf of Mayor Harrison, who was unable to be present.

President Tait then delivered his address, which had to do principally with association matters and the problems incident to conducting the affairs of this great organization which has grown in membership from 1300, five years ago, to over 12,000 at the present time.

The class "A" or company memberships to the association decreased from 1136 last year to 1093 because not enough new members were secured to offset the 118 resignations received due to the consolidation of many properties. A large number of papers, committee reports, lectures and addresses on subjects of importance to public light and power people were presented during the 19 general and sectional sessions of the convention. Many of these are offered in brief abstract herewith; others of more general interest will be given fuller treatment in later issues.

METER COMMITTEE REPORT

This consisted of a 47-page pamphlet reviewing the past year's work of the committee. A standard dial-face for watt-hour meters is recommended. The effect of using induction watt-hour meters on frequencies other than those for which they were designed has been studied by the committee. As a result, it is pointed out that when changing a system from a high to a lower standard frequency, the meters should be changed first and vice versa, thus safeguarding the potential circuits against undue heating or burnouts.

Another subject studied was that of metering rapidly fluctuating loads. A feeling exists that in such cases the meter fails to register all the current used. Although unable actually to conduct tests, the committee, because of information gathered, stated that there appears to be no error with the commutator type of meter. On the other hand, with the induction type, it is claimed that there is a slight tendency to register a small amount of energy in excess of that actually used—so small, however, as to be practically negligible as the error falls well within 1½ per cent., except in extreme cases.

The report also contained recommendations to use more uniform connection diagrams for instrument transformers and descriptions of the latest meter developments.

With the report was submitted the third edition of the "Code for Electricity Meters," containing nine sections, devoted to definitions, standards and measuring instruments, metering, specifications, installation methods, tests and maintenance methods.

GROUNDING SECONDARIES

After working six years the committee on grounding secondaries has secured a unanimous agreement to the desirability of grounding secondary circuits and has succeeded in having the National Electrical Code revised so that a rule now requires the grounding of such circuits having a potential of 150 volts or less. The committee recommends as the best ground a solid connection to underground metallic piping systems, making these connections where they can be periodically inspected.

LAMP REPORT

The lamp committee reported that conditions indicate the rapid substitution of the metallized and mazda lamps for the carbon. A rapid improvement in the quality of the tungsten-filament lamps and a constantly downward tendency in their price have been features of the past year. The trade name "mazda" has now been generally adopted by American manufacturers for this type of lamp.

PROGRESS IN LAMP MAKING

J. E. Randall and Evan J. Edwards presented a paper dealing specifically with the recent progress made in the art of incandenscent lamp manufacture. The rated specific consumption of regular lamps has been reduced by about 0.15 watt per candlepower on the larger lamps through the careful use of chemicals which retard the blackening of the bulb. Such improvements have made it practicable to employ smaller bulbs for a given wattage.

In discussion of this paper John W. Howell brought out the point that the present 60- and 100-watt lamps give double the life at the efficiency of a year ago, and that the 10-watt standard-voltage lamp is five times as good as a year ago.

MEASUREMENTS AND VALUES

The report of the committee on the above subject discussed, without making any specific recommendations, the recent efforts of various engineering societies to unify and simplify standards, units and the terminology of power. Particular reference was made to the proposal to abandon the term "boiler horsepower" and adopt "myriawatt." In the ensuing discussion, Dr. Steinmetz, in a semi-humorous vein, deprecated the addition of new units of a more or less unscientific nature to existing terminology.

INCANDESCENT LAMPS AND LIGHTING SERVICE

In a paper under this head M. D. Cooper and Robert C. Campbell pointed out the need of greater care in laying out wiring for lighting installations as, with abnormal voltage drop, rated efficiency is not secured.

HYDRO-ELECTRIC SESSION

"The Failure of Conservation to Conserve," a paper by E. H. Thomas, Seattle, presented at the first hydro-electric and transmission session, Wednesday morning, arraigned the conservation policies sponsored by Mr. Pinchot and ridiculed the idea of a trust controlling the water-power field.

WATER-POWER PROGRESS

Following this paper the report of the committee on progress was presented by Secretary Martin in which various decisions and utterances of public authorities in regard to water-power matters were quoted and the more important features of improvement in hydro-electric engineering were reviewed. A phase of the latter portion of the report which brought out some discussion was that quoting the recommendations of official Swedish engineers of the direct-current method of transmission for a 200-mile line between Trolhatten Falls and Copenhagen, Denmark, with a potential of 90,000 volts. The consensus of opinion of those who discussed this proposition was that while direct current may offer advantages in this special case in a large majority of cases alternating-current is preferable for long-distance work, principally because of the practical limitation with the direct-current system, due to commutation difficulties, to machines of not more than 1500-kw. rating.

REPORT ON WATER TURBINES

The report of the subcommittee on prime movers pointed out that the newly developed Kingsbury thrust bearing, described in "Power" for May 13, and a new form of combined oil-presure and roller-thrust bearing together with recent advances in the design of water-wheel runners tend to improve the service of the vertical turbine. The subject of runner material was considered to some extent but left open to further discussion. Further investigation was recommended on the subject of steam-flow measurement and wheel consumption and, incidentally, a paper, to be abstracted in a later issue of "Power," by C. M. Allen, of Worcester Polytechnic Institute was presented on "Efficiency Tests of Water Wheels after Installation."

CENTRAL-STATION POWER IN COAL MINES

In a paper under this title W. A. Thomas contended that in spite of the low fuel cost in an isolated power plant of a coal mine, the substitution of central-station current can be made with profit to both mine operator and central station. The reason claimed for this is that the cost of carrying the isolated plant investment over the light-load periods makes the privately manufactured current more expensive than purchased power. In addition it is claimed that the central station can profitably sell current for mine service at a low price because the load is mostly an off-peak one, hence, investment expense is small.

SWITCHING APPARATUS FOR RURAL INSTALLATIONS

This paper, by E. B. Merriam, describes semi-portable and portable substations for supplying power from existing high-voltage transmission lines and consisting of inexpensive but reliable outdoor fuses, switches, transformers, switch houses and other required devices. The development of such apparatus opens, a wide field for the sale and application of current to villages and small towns, mines, quarries, farms, irrigation and drainage work and the like.

ELECTRIC SERVICE FOR SMALL TOWNS

A paper by J. Edward Kearns suggests that by consolidating a number of small light and power systems and distributing the current from one central station instead of a number, many advantages are often secured and formerly unprofitable systems often may be put on a well paying basis. In addition, with such consolidation, it is frequently possible to serve certain classes of customers whom the small independent plant cannot afford to serve. The paper contains suggestions as to estimated costs both of construction and operation.

REPORT ON PRIME MOVERS

At the Thursday morning technical session the report of the committee on prime movers was presented by Chairman I. E. Moultrop. The report called attention to the progress being made in steam-turbine design in the direction of larger capacities and improved efficiency. A highly efficient horizontal type of Curtis machine for speeds of from 1200 to 1800 r.p.m. has been developed and several of 20,000-kw. capacity, each, are on order, while the designs of even larger units have been completed.

A so called cross-compound type of Parsons turbine has been evolved, consisting of two separate sections, as far as the steam and electrical ends are concerned. The high-pressure end operates, for instance, at 1800 r.p.m. and develops 15,000 kw., while the low-pressure section, receiving the exhaust from the high after the moisture due to expansion has been removed, operates at 720 r.p.m. and develops an additional 15,000 kw. Both sections are under the control of the governor and the high-pressure admission valves. It is said that the result of this design is a greater thermal efficiency, based on the output at the generator terminals, than with any other arrangement.

It is said that noncondensing turbines continue to grow in favor for certain classes of work and the use of the small turbine for driving station auxiliaries—exciters, feed and other pumps and blowers—is constantly spreading.

Favorable mention is made of Dr. Ferranti's turbine in which the steam is maintained in a perfectly gaseous state during its entire travel through the machine by the use of high initial superheat and reheating between first and second stages. It is reported that the steam consumption of this machine will fall below 6 lb. per steam brake-horsepower-hour.

The opinion expressed in the report of a year ago in reference to high-efficiency and self-contained units like the Stumpf, Wolf, Lentz, Locomobile and Memming engines is reiterated and the committee states that such types do not appear to be adaptable to American conditions.

The condenser design prevailing in some directions requires modification, in the opinion of the committee, because of the high degree of vacuum desired in turbine work. Passages of ample cross-section are required so that the steam may have immediate and free access to all portions of the cooling surface at moderate velocities and without following a constricted and tortuous path around baffles and between tubes.

The report further contained reference to numerous new devices and steam-plant practices which have been illustrated and discussed in "Power" from time to time.

Nothing new in the gas-power field was reported but considerable space was devoted to oil engines and statistics on the general oil supply. An important rise in the price of oil is noted and a slight falling off in production in some sections is pointed out. Faith in the heavy-oil engine continues to grow and strengthen and the number of manufacturers engaged in its development continues to increase, several additional large concerns having recently entered the field.

ELECTRICAL APPARATUS

Following this report, L. L. Elden presented the report of the committee on electrical apparatus—a 48-page pamphlet dealing comprehensively with the latest developments in generators, exciters, motor-converters, transformers, regulating apparatus, etc. High-voltage generators of large capacity to operate without auto-transformers are now available and 25,000-kw. units have become standard. Feeder regulators are increasing in efficiency and out-door regulation is a new development. New types of reverse-current relays are being brought out and increased life is being secured of rectifier tubes, principally through the use of double equipments, insuring continuity of service. Current-limiting reactances, speed of rotative apparatus, direct-coupled exciters, the use, care and life of various types of brushes and the application of motor-converters were among other topics treated. A technical discussion is also contained on the merits of several arrangements of central-station testing apparatus.

In the ensuing discussion it was stated that the new 30,000-kw. turbine set of the Commonwealth Edison Co. will deliver current at 9000 volts without an auto-transformer equipment, thus increasing the efficiency by 0.6 per cent. Noise caused by the operation of substation machinery was discussed and it was asserted that there was room for the manufacturers to effect improvement in this direction. The subject of reactances was also discussed with especial reference to the use of such apparatus for bus section and interstation service.

OVERHEAD LINE CONSTRUCTION

The joint report of committees representing five large engineering societies, on overhead line construction, contained full specification for overhead crossings of light and power lines and signaling circuits involving protection against potentials of 5000 volts or more. Reliable data are also included in regard to sags, factors of safety in line construction, conductors, insulators, poles, foundations, galvanizing, properties of wire, etc.

SWITCHBOARD INSTRUMENTS

A paper under this title by Paul MacGahn outlined the desirable features of switchboard instruments and emphasized the economy in space made possible by the use of induction types of apparatus. In addition, the freedom of such types from the influences of stray fields was pointed out.

E. G. Reed presented a paper on "The Latest Developments in Distributing Transformers," in which better winding and coil insulation were mentioned as being factors. The chief improvements, however, result from the use of guttered winding with the machine type of coil, improved machine-formed insulating barriers and the arrangement of oil-circulating ducts. Lower iron and copper losses have been secured and at the same time the insulation is better.

An interesting paper by Angus S. Hibbard on "Telephonic Communication, the Means of Control of Central Stations" was next presented. This described the elaborate use of telephone service in load dispatching as employed by the New York Edison Co.

In a paper entitled "The Central Station's Greatest Opportunity—the Electric Vehicle," E. E. Witherby emphasized the desirability of the electric-vehicle load from a central-station point of view and urged that central-station people do all within their power to foster the use of this type of automobile.

The report of the committee on electricity in rural districts was a voluminous and well illustrated work. In general, it indicated that relatively little has been accomplished in the way of profitably developing truly rural business.

In a paper on "Poles and Pole Preservation," R. A. Griffin pointed out the necessity for greater attention to the question of a preservative treatment of poles in permanent lines and reported some actual results thus far obtained.

DEVELOPMENTS IN PROTECTIVE APPARATUS

This is the title of a paper presented by J. W. Mahoney describing improvements in oil and carbon circuit-breakers and lightning arresters due to the high voltages and generating capacities now in general use. A large number of types and sizes are provided to meet various breaking-capacity requirements at voltages up to 165,000 and conducting capacities up to 4000 amperes. Design and constructional improvements for moderate capacity and voltage service include porcelain insulating pillars, clamped in position, contact details clamped thereto, use of removable separate arcing contacts, heavy steel-plate tanks with lap-welded joints, greater volume and head of oil, and strong tank-supporting details. Medium voltage and capacity breakers have, in addition, individual tanks per pole, on either a single multiple frame or individual frames for each pole, "butt" type high contact pressure laminated brush contacts self-cleaning, "butt" type solid arcing tip situated to reduce the arcing to a minimum. High-capacity, medium-voltage breakers have elliptical or round tanks, in which the metal is used in tension, of the strongest construction. Expansion chambers and appropriate vents are provided for the arc gases in all designs. For very high capacity and voltage a breaker having self-contained reactance cut into circuit on operation of the breaker is now standard.

Carbon breakers are now made in standard capacities from 3 to 24,000 amperes and up to 1500 volts direct current. Modern types include the "butt" wiping form of laminated brush with metal secondary contacts and "butt" and wiping carbon final contacts. A new feature in a line of breakers for moderate conducting and breaking capacity is the use of pressed-metal parts nearly throughout. The heavy-service breakers, for the higher currents and voltages, have several steps of increasing resistance in shunt to the main contacts, are provided with ventilating passages between the several brush units, which also reduces the skin effect on alternating current, and use the laminated or "busbar form of terminal stud. The aluminum electrolytic arrester has displaced all others for severe service. Daily charging is the usual practice and the so called "charging resistance" is used quite generally where the surges due to charging might cause trouble. An inorganic electrolyte and the annular form of tray have demonstrated their effectiveness.

STREET LIGHTING

The report of the committee on this subject is divided into three main sections: (1) Brief review of the history of street-lighting specifications. (2) Discussion of various proposed methods of measuring illuminating power of street lamps. (3) Recommendations on drawing contracts for street lighting. In many instances, contract clauses which, when accepted, were fair to all parties concerned and would have fulfilled all terms of the contract under previously existing conditions, have proven unsatisfactory due to the introduction of new illuminants and new conditions. To avoid controversy in the future certain definite principles of contract form are suggested.

RECENT DEVELOPMENTS IN FLAME ARC LAMPS

A paper on this subject discussed flame carbon-arc lamp design from the standpoint of the operating and central-station man. Attention was also given to indicating how friction may be largely eliminated in the regulation of such lamps and some requirements of good operation were noted with an explanation of the manner in which these requirements may be met.

COPPER-CLAD WIRE FOR SERIES ARC LIGHTING

In a paper dealing with this topic, T. K. Stevenson pointed out the advantages of copper-clad steel wire for overhead circuits. This wire, in contrast with other types, has the advantages of being practically non-stretching and having a small coefficient of expansion.

UNDERGROUND CONSTRUCTION

The committee report on this subject this year dealt exclusively with high-tension cables and discussed periodic testing, carrying capacity, graded insulation, sector conductors, current-limiting reactances, protection of cables in manholes, parallel routes, trouble reports, practical hints as to operation and specifications for paper- and rubber-insulated cables for underground operating pressures in excess of 2000 volts. Considerable space was given to carrying capacity, and recommendation is made of a very decided increase in rating during the winter; also that the current rating be varied inversely with the voltage, on account of the heating in the insulation due to the leakage of current. The report intimated that in paper cable American manufacturers are in some respects behind European, as evidenced, for example, by the bending test. In European cables the bending test is applied three times. American manufacturers consider as too severe, a test of bending first in one direction and then in the other, twice repeated, to a radius of six times the cable diameter. The specification presented in the report increases the radius of bending to 7½ times the cable diameter.

DISTRIBUTING LINES

In the committee report on the above, voltage is not considered as a limiting factor. Voltages which a short time ago were not considered commercial possibilities are today being used not only on long transmission lines but very generally for distributing purposes. Star and delta connections, alternating and direct current, the use of batteries and of the turbine for both reserve and regulating purposes, are all given attention in connection with the problem as a whole.

A satisfactory way of carrying two circuits on the same line of poles is given. The use of iron wire is suggested where load is small and voltage regulation not of great importance, as in reclammation and irrigation work.

The rather severe requirements of the California Commission with regard to crossing construction are discussed. The relation of gross revenue to cost of investments in new line extensions is studied in its connection with long-time contracts with customers. Sometimes the extension might be made on the basis of gross revenue for five or an even greater number of years equaling the investment. The percentage of power bills rebated averages from 20 to 25.

TRANSMISSION-LINE CONSTRUCTION

The paper on this subject presented by R. C. Coombs relates primarily to transmission lines carrying voltages above the 2300-volt class. In general the construction or structural features are considered rather than the electrical or operating conditions. The author considers the physical characteristics of a pole or tower line as deserving of careful attention and believes that a too hasty inclusion of mechanical limitations in a specification may result either in disproportionate expense to the industry or in transmission lines of inadequate strength.

OPERATION OF WATER-POWER SYSTEMS

In the Committee report on this subject it was stated that the rapid increase in hydro-electric development in recent years and the growing importance of this power service is setting new operating standards. It is now fully realized that the success of such developments can be obtained only by giving a most reliable and uninterrupted service and the safeguarding of the different parts comprising the system, therefore, becomes of the greatest importance.

The efficiency and reliability of operating forces is without question one of the greatest assurances for a satisfactory operation, and it is also intimately connected with the means which are provided for communication.

The general layout of the system is naturally also an important factor. This refers to the capacities of the different generating stations, to the water conditions, to the characteristics of the load, etc. Practically no hydro-electric development with the capacity of installed apparatus above the rating at minimum stream flow is nowadays attempted with-

out a steam station on the system. Such a steam station may be used as an auxiliary station at periods of low water, as a reserve in case of interruptions, or as a regulating station to take care of the variations in the load with the hydro-electric plant running at constant output.

Consideration must also be given to the causes of disturbances and means for minimizing their effects. These are abnormal or so called emergency conditions, and in treating of them, the failure of every piece of apparatus and part of the system must be considered as a possibility and a definite plan worked out for limiting the magnitude and area of such disturbances.

TRANSFORMERS FOR POWER TRANSMISSION

This is the title of a paper by Harold H. Rudd. The great tendency at the present time toward centralization of power is making many interesting problems on power distribution. The voltage chosen for distribution must be high enough for economical transmission and not so high that the cost of a complete substation installation makes it impractical to install those of small and moderate capacity.

The development of the outdoor transformer with the necessary switching and protective devices has made it possible to use installations of small capacity at a high voltage and at very moderate cost.

The paper gives a curve of costs for installations of different capacity for various voltages. It shows that where the transmission lines feed a number of small communities, the economical voltage is 22,000 or 33,000. The saving by the use of an extremely small size transformer is so slight in comparison with the total cost of installation as to be negligible.

There is a wide variance in characteristics demanded by the different power stations, more particularly as regards voltage variation and taps. Great extensions are being made in the use of all transformers, hence, there is a need of standardization as regards taps. Such standardization will result in much good to the industry at large, to the manufacturer and the customer.

RAILWAY LOADS FOR CENTRAL STATIONS

The last technical paper presented at the convention was by E. P. Dillon on "Electric Railway Loads on Central Stations." Attention was called to the desirability of railways, both city and interurban, as power customers for central stations. In some of the larger cities the problem has been very thoroughly worked out and excellent results obtained by combining the requirements of the two classes of service on one generating system.

ELECTION OF OFFICERS

By constitutional amendment provision was made for two additional vice-presidents. The election of officers resulted as follows: President, J. B. McCall, Philadelphia, Penn.; first vice-president, John A. Britton, San Francisco, Calif.; second vice-president, H. H. Scott, New York City; third vice-president, E. W. Lloyd, Chicago, Ill.; fourth vice-president, E. C. Deal, Augusta, Ga.; treasurer, W. F. Wells, Brooklyn. The secretary is appointed by the executive committee.

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A liquid rheostat for large alternating-current motors has recently been developed by the Westinghouse Electric & Manufacturing Co., to supply the demand brought by the use of large slip-ring motors driving mine hoists, winding gears, rolling mills, etc. Such a rheostat provides an infinite number of speed steps between limits and permits smooth acceleration. This particular design comprises two compartments, an upper tank for immersing the electrodes and a lower storage reservoir. The small motor-driven pump maintains a steady stream of liquid, usually an alkaline solution, from the lower reservoir into the upper tank, the latter discharging its contents back into the former over a weir, which takes the form of a tube that can be raised or lowered through the floor of the electrode tank. By raising or lowering the weir the height of liquid in the electrode tank is varied and resistance between electrodes changed as desired. The operating lever of the rheostat controls both the weir and a master switch, which opens and closes the primary circuit of the motor. A valve in the intake pipe of the electrode tanks regulates the rate at which the liquid can be pumped in, so that no matter how quickly the operating arm is thrown over the liquid can rise in the tank only at a definite rate, thus fixing the rate of acceleration. Cooling coils for circulation of water are introduced in the lower reservoir to prevent overheating and rapid evaporation. The capacities so far designed are from 400 to 1500 hp. of controlled motor.

New York State N. A. S. E. Convention

The 18th annual convention of the New York State Association of the National Association of Stationary Engineers was held at Yonkers on June 12, 13 and 14, in the Armory.

On Thursday, June 12, the exhibition hall was opened to the public with appropriate speeches and was well attended.

The regular business meeting was held on Friday morning, Chairman Louis Bernard presiding. The Hon. James T. Lennon, mayor of Yonkers, welcomed the delegates, National Vice-President James R. Coe responding. Other addresses were made by the Hon. Nathan A. Warren, president of the Chamber of Commerce; State President George O. Kaley, Past National President William J. Reynolds, Past National President Edward Kearney and ex-State Senator Louis Munzinger.

On Saturday, June 14, the usual business session was held. In the afternoon, with the Otis Elevator Co. as host, a frolic at Kinross was given the members and their guests. There were many amusements furnished and refreshments were served. The Otis company was declared to be a most hospitable host, and all returned greatly pleased with the outing.

A vaudeville entertainment was given in the exhibit hall on Friday evening, and was well patronized. Among the entertainers were Joe McKenna, of Jenkins Bros.; Jack Armour, of "Power"; Mr. Martell, of the Peerless Rubber Co.; Maybelle Burke, Frank Corbett and the Dixie Four. Frank Martin was stage manager.

The following officers were elected for the ensuing year: Past president, George O. Kaley; president, Edgar E. Pruyn; vice-president, Fred Felderman; secretary, William Roberts; treasurer, William Downs; conductor, Elmer Hartley; doorkeeper, Joseph Burback.

The convention for 1914 will be held in Buffalo.

The committee of arrangements were: Louis Bernard, chairman; Frank Connolly, William Tompkins, James T. Roberts, Thomas Sharp, David Murray, Albert Serrell, Joseph C. Ryan, Wm. Roberts, John Buckley, David Thompson, Charles Wittemore, John Lewis, Frank Reiger, Harry Wallace

THE EXHIBITORS

Albany Lubricating Co.
V. D. Anderson Co.
American Engine Co.
Armstrong Cork Co.
Ashton Valve Co.
A. B. Barr
W. M. Bastable Co.
J. H. Banks & Co.
Bayer Steam Soot-Blower Co.
F. S. Bowser Co.
Buhne Metal Packing Co.
Boig & Hill
Broderick & Bascom Rope Co.
C. T. Coe Co.
Chamber of Commerce
Chapman Valve Co.
Crandall Packing Co.
Coppus Engineering Co.
M. T. Davidson Pump Co.
Dearborn Chemical Co.
Danubil Co.
Diamond Power Specialty Co.
Eddy Valve Co.
Erie City Iron Works
Economy Fuse & Mfg. Co.
Fairbanks Co.
Felber Engineering Co.
D. W. Freeman
Garlock Packing Co.
Greene, Tweed & Co.
Griscom-Russell Co.
Greenpoint Fire Brick Co.
Grieve Grate Co.
Hewes & Phillips Iron Works
Homestead Valve Co.
Hazard Mfg. Co.
Home Rubber Co.
Harrison Safety Boiler Co.
Jenkins Bros.
H. W. Johns-Manville Co.
Keystone Lubricating Co.
Kieley & Mueller
Ladew Estate
Ladies' Auxiliary
Lagonda Mfg. Co.
Lunkenheimer Co.
William Martin
McLeod-Henry Co.
H. Mueller Mfg. Co.
McCord Mfg. Co.
W. B. McVicker Co.
Harry Marks
I. R. Nelson
"National Engineer"
N. Y. Belting & Packing Co. (Ltd.)
Otis Elevator Co.
J. O'Meara, Inc.
"Power"
Peerless Rubber Co.
Perolin Co.
F. B. Potterton
"Practical Engineer"
Pitts & Kitts Mfg. & Supply Co.
Philadelphia Grease Co.
Quaker City Rubber Co.
J. L. Quimby & Co.
Clement Restein Co.
Roebling Wire Rope Co.
J. C. Ryan
Russell, Birdsall & Ward
Skinner & Connolly
C. E. Squires Co.
L. Sonneborn Sons
"Southern Engineer"
Shipley Construction & Supply Co.
Standardizing Co.
Texas Co.
Thread Tight Co.
H. L. Twine
U. S. Graphite Co.
United Metal Hose Co.
F. W. Webb
West Disinfecting Co.
Washburn & Granger
The Waite Co.

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Ontario's New Boiler Regulations

Effective July 1, will be the regulations recently passed by the Province of Ontario, Canada, relating to the construction and inspection of boilers. To D. M. Medcalf, public inspector of boilers for the province, manufacturers of boilers to be used in the province must henceforth submit plans and specifications to show that both the material and manner of constructing accord with the prescribed standards. All new boilers must so conform and second-hand boilers to which extensive repairs have been made will also be inspected.

Smoke Inspection in Milwaukee

The annual report of Charles Poethke, smoke inspector for the city of Milwaukee, Wis., has recently been made public.

The following details part of the work done by that department for 1912: Smoke charts taken, 82; photographs taken, 400; written warnings, 96; letters written, 236; letters received, 245; complaints received, 59; cases dismissed on technical error, 0; cases dismissed (not guilty), 0; sentences suspended on payment of cost, 14; cases in court fined $25 and costs, 41; cases in court fined $50 and costs, 5; cases in court, second offense in 1912, 6; total number in court, 60; total fines imposed, $1275. The maximum minutes of dense smoke recorded where legal action was brought was 35 min. in one hour; the minimum 11½ min.

There were 1452 observations of chimneys and stacks made and recorded as follows: January, 15; February, 30; March, 75; April, 83; May, 100; June, 152; July, 129; August, 191; September, 134; October, 149; November, 201; December, 193. Forty permits were issued for remodeling and new installations of furnaces.

Of the offenders there were 22 manufacturers, six coal companies (yards), three woodworking plants, one brewery, three electric-light companies, one store, one department house, one laundry, two tanneries, three office buildings, four boat lines, one tug-boat company, one dredge and pile-driving company, one grain elevator, four flour mills, two asphalt plants.

The Chicago, Milwaukee & St. Paul R.R. employs two smoke inspectors, and the Chicago, Northwestern Ry. one, each paid by its company. Their duty is to instruct firemen how to fire with least possible smoke. If found negligent in keeping down dense smoke, whether they violate the city ordinance or not, the firemen are either reprimanded or suspended for from five to thirty days without pay or discharged. The railroad inspectors report on their work to the city smoke department twice a week, and also to receive complaints or any other information.

"To increase the efficiency of the department," states the inspector, "a motor boat should patrol the three rivers, as this is the only effective method of obtaining evidence on account of the moving boats. At present these violations can only be obtained when boats are docked, and while being tied up they, as a rule, avoid excessive smoke.

"A small automobile is also necessary to cover the city and especially to have control of the one-mile zone which covers an additional area of 17 square miles. Smoke, soot and cinders are deposited during the night and can be found on the walks in the morning. This is a nuisance; the only way of relief is by an automobile. The same should be equipped with a searchlight which can be directed upon chimneys and stacks under suspicion of committing these nuisances after dark. A few such cases brought before justice would undoubtedly find a discontinuance in a short time."

The department consists of the smoke inspector, two deputies and one clerk-photographer.

PERSONALS

George H. Burke, for several years manager of the New York office of the Sarco Engineering Co., will open an office in Chicago, July 1, to take care of the firm's business in the Middle West.

M. Plunkett, master mechanic of the Choctaw Railway & Lighting Co., McAlester, Okla., has had his jurisdiction extended over the maintenance of equipment and the power station, succeeding N. E. Daniels, chief engineer of the power station.

SOCIETY NOTES

The date for the Michigan State N. A. S. E. convention at Grand Rapids has been changed from June 18, 19 and 20 to Aug. 6, 7 and 8.

On June 10, 114 young men received the degrees of Lehigh University in technology and in arts and sciences at commencement exercises held in Packer Memorial Church. President Henry Sturgis Drinker conferred 36 degrees in civil engineering, 17 in mechanical engineering, 17 in mining engineering, nine in electrical engineering, eight in electrometallurgy and metallurgy, five in chemistry and chemical engineering, three of bachelor of arts, and seven of bachelor of science. The last includes the first graduates in Lehigh's new course in business administration. Nine degrees of master of science were conferred and three of master of arts.

NEW PUBLICATIONS

ENGINEERING THERMODYNAMICS. By C. E. Lucke, professor of mechanical engineering at Columbia University. Published by McGraw-Hill Book Co., New York. Size, 6x9 in.; 1176 pages, illustrated, cloth. Price, $8.

This book is probably the most extensive work ever published on the subject of engineering thermodynamics. It is difficult, however, to determine which class of readers it is intended to serve. As a textbook for undergraduate college courses in thermodynamics, it is hardly suitable on account of its bulk, but it should prove useful as a supplementary text for graduate students in mechanical engineering. It contains 143 very complete tables and numerous diagrams, charts and equations. An alphabetical index to the tables and charts would be an improvement.

The subject matter of the book is treated in three parts. The first deals with work without consideration of heat changes; the second takes up the heat and the third part is devoted to the relation between heat and work. The elementary principles of physics as applied to work and power are explained, more space being given to the solution of simple problems than would prove of value to one taking up the study of thermodynamics. The part dealing with the dynamics of nozzles and jets is very practical.

The determination of the work done in compressor cylinders is then considered, and formulas are derived for the single-stage, two-stage and three-stage compressors, for cycles with isothermal compression, and for exponential compression, with and without clearance. The author might have saved space and avoided repetition of the formulas by working out only the most important cycles, and leaving the other cases as problems to be solved by the student. Charts for the graphical solution of compressor problems are included.

The work available in engine cylinders is taken up at great length, and the action of fluids in single- and multi-expansion engines is clearly illustrated by numerous problems. The engine cycles analyzed in this part include those with logarithmic and exponential expansions with and without clearance for simple engines, compound engines with finite receiver, compound engines with infinite receiver, compound engines without receiver, and triple-expansion engines. The part devoted to the general case of multiple-expansion and to consumption of steam engines is well presented.

Under the heading "Heat and Matter," will be found a great deal of valuable data and uptodate information. The part dealing with the properties of ammonia is especially good. Other items treated very fully are specific heats of gases and vapors, properties of vapors and combustion. Too much space seems to be given to the fundamentals of thermometry. Also the properties of gases and vapors might have been treated independently of each other to avoid confusion.

In connection with the thermal processes a very exhaustive study is made of the properties of solid, liquid and gaseous fuels, and of their comparative heat values. The gasification of fuels is treated clearly and at great length, this including gasification of solid fuels by air-blast alone, by steam blast alone, and by a combination of steam and air blast reactions, producing air gas, water gas and producer gas respectively. The burning of fuels with draft under boilers, evaporation and heat balance in steam generators are taken up in detail. This part of the book includes the results of the most recent experiments on the gasification of fuels.

The last part deals with the relations between heat and work. Much space is given to the methods of plotting entropy diagrams, and to the comparison of steam and gas cycles, plotted between entropy-temperature and pressure-volume coördinates. The thermal efficiency and performance of various heat engines are compared. The part dealing with the flow of vapors and gases is good. The subject of mechanical refrigeration includes excellent charts and diagrams, but is treated rather too briefly.

The book contains an immense amount of valuable uptodate information presented in a very original manner. The arrangement of the subject matter might have been improved, however, if the parts dealing with the work in compressors and engine cylinders were placed after the chapters dealing with heat, or still better if abbreviated and treated in connection with that part which takes up the relation between heat and work.

NEW EQUIPMENT

ATLANTIC COAST STATES

Plans are being prepared by Sterrett & Brunner, 156 State St., Boston, Mass., for the construction of a power plant to generate 2000-hp. to be erected on the new fish pier at South Boston. William J. O'Brien is interested.

The town council of Blairsville, Penn., is considering plans for the construction of an electric-light plant.

Plans are being considered by the Philadelphia Rapid Transit Co. for the construction of a power plant at 13th and Mifflin Sts., Philadelphia, Penn. Estimated cost, $30,000. W. L. Maize is purchasing agent.

SOUTHERN STATES

The city of High Point, N. C., contemplates the installation of additional equipment for its electric-light system. H. C. Bulla is manager.

The Southern Power Co. is considering plans for the construction of a substation at Rock Hill, S. C. W. R. Connell, Charlotte, N. C., is purchasing agent.

The improvement of the municipal electric-light plant and water system at Bastrop, La., is under consideration. J. K. Skipworth is mayor.

CENTRAL STATES

The managers of the electric-light board of Anna, Ohio, are considering plans for the installation of additional equipment in the municipal electric-light plant. T. S. Price is clerk of the board.

If granted a new franchise the Cleveland, Southwestern & Columbus Ry. Co. will expend $20,000 for the improvement of its power plant at Norwalk, Ohio. C. G. Taylor is superintendent.

The proposition to issue $20,000 in bonds for the improvement and installation of new equipment in the municipal electric-light plant at Bluffton, Ind., is under consideration.

The Grand Rapids-Muskegon Power Co. contemplates the construction of a substation at Wealthy St. and Indiana Ave., Grand Rapids, Mich. Estimated cost, $18,000. A. F. Walker is superintendent.

The American Car & Foundry Co. will build a one-story power plant in connection with its establishment at South Wood and Paulina Sts., Chicago, Ill. Estimated cost, $5400.

The village board, Manito, Ill., is considering plans for the construction of an electric-light plant.

BUSINESS ITEMS

Orenstein-Arthur Koppel Co. has given the agency for its Canadian business to the Canadian Fairbanks-Morse Co., Ltd.

John U. Higinbotham is now assistant treasurer of the Detroit Lubricator Co., Detroit, Mich.

TRADE CATALOGS

J. Faessler Mfg. Co., Moberly, Mo. Catalog No. 32. Boilermakers' tools. Illustrated, 40 pages, 6x9 in.

Falls Machine Co., Shebofgan Falls, Wis. Pamphlet. Automatic engine stop. Illustrated, 24 pages, 5x8 in.

American Engine Co., Bound Brook, N. J. Pamphlet. "A New Paper Mill Engine." Illustrated, 16 pages, 6x9 in.

The Weber Chimney Co., McCormick Building, Chicago, Ill. Catalog. Reinforced-concrete chimneys. Illustrated, 48 pages, 5x9 in.

The Climax Smoke Preventer Co., Equitable Building, Boston, Mass.—Catalog. Smoke preventer. Illustrated, 20 pages, 6x9 in.

The Heine Chimney Co., 72 West Adams St., Chicago, Ill. Catalog. Interlocking radial brick chimneys. Illustrated, 32 pages, 4x9 in.

Harrison Safety Boiler Works, Philadelphia, Penn. Booklet. Evolution of the Cochrane Multiport Valve. Illustrated, 52 pages, 3x6 in.

John F. Swan, 10th St. and Duncannon Ave., Philadelphia, Penn. Pamphlet. Hawley down draft smokeless furnace. Illustrated, 5x8 in.

Clayton Air Compressor Works, 115 Broadway, New York. Bulletin No. C-210-S, printed in Spanish. Air Compressors. Illustrated, 32 pages, 6x9 in.

The Blake & Knowles Steam Pump Works, 115 Broadway, New York. Catalog B-K 876. Single direct-acting pumps. Illustrated, 84 pages, 6x9 inches.

Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 128. Miscellaneous equipment for pneumatic drills. Illustrated, 12 pages, 6x9 in. Bulletin No. 132. Pneumatic motors and pneumatic geared hoists. Illustrated, 20 pages, 6x9 in. Bulletin No. 133. Cylinder air hoists and jacks. Illustrated, 12 pages, 6x9 in.

The Bristol Co., Waterbury, Conn. Bulletin No. 132. Recording differential pressure gauges and recording flow-rate meters. Illustrated, 16 pages, 8x10½ in. Bulletin No. 170. Patent electric furnaces for soldering coppers. Illustrated, 2 pages, 8x10½ in. Catalog No. 1300. Class III recording thermometers. Illustrated, 48 pages, 8x10½ in.

WANTS

Positions Wanted, three cents per word, each insertion
Positions Open, five " " " " "
For Sale, five " " " " "
Miscellaneous, ten " " " " "
No abbreviated words allowed.
Count three words for keyed address.
All advertisements payable in advance.

Copy should reach us not later than Tuesday 10 A. M., for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York, will be forwarded.
No information given by us regarding any advertiser's address. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondent.
No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for positions.

POSITIONS OPEN

SALESMAN—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M.M. Co.," Power.

AGENTS to sell on commission mechanical draft blowers; prefer men who handle on similar basis sales of grate bars, tube cleaners or other boiler accessories; hustlers wanted; state experience and territory worked. P. 855, Power.

POSITIONS WANTED

ERECTING FLOOR FOREMAN by an erecting engineer, at present employed on large size units. P. W. 916, Power.

ELECTRICIAN, 23; steady position power plant or contracting concern; eight years' practical experience wireman and maintainer; will go out of town. P. W. 920, Power.

CHIEF ENGINEER, age 32, holding responsible position, desires change; first-class Ohio license; married; strictly sober; South or Central States preferred. P. W. 919, Power.

A TECHNICAL MAN wants position as superintendent of an electric-lighting and refrigerating plant; age 34; good reasons for changing. P. W. 915, Power.

A MECHANICAL ENGINEERING GRADUATE wants position as superintendent of power, or master mechanic with a manufacturing firm; 11 years' varied experience; now employed. P. W. 914, Power.

BY AN ELECTRICAL, MECHANICAL AND EFFICIENCY ENGINEER, who has had 20 years' experience in teaching, designing, constructing, operating and managing; graduate Cornell, and member American Society of Mechanical Engineers. P. W. 912, Power.

MANUFACTURERS REPRESENTATIVE, favorably known and of wide experience in modern engineering, wishes to handle power-plant equipment, engines, boilers, stokers, etc., in Pittsburgh district. Daniel Ashworth, M. E., 1225 Fulton Bldg., Pittsburgh, Penn.

FOR SALE

20x42 HUGHES & PHILLIPS tangye frame Corliss engine; cost $4000; like new; $1200. Duzets & Son, Hudson Terminal, New York.

20x42 LANE & BODLEY HEAVY DUTY CORLISS ENGINE; condition like new; $900. Eastern Machinery Exchange, 171 Broadway, New York.

ONE 150-HP. FISHKILL CORLISS ENGINE and flywheel; one 150-hp. return-tube boiler; one 7½x8½x12-in. Deane steam fire pump; all in very good condition. Apply Barnet Leather Co., Little Falls, N. Y.

GAS ENGINE, 225 hp. American Crossley horizontal double cylinder, opposed 22x30 in., with Akerlund producer; located Columbia, S. C.; selling account cheap hydro-electric power; bargain. F. S. 904, Power.

THE FOLLOWING DIRECT CONNECTED UNITS: 20KW, 125 Volts; 40KW, 125 Volts; 100 KW, 250 Volts; 150KW, 250 Volts; 200KW, 250 Volts. Corliss Engines: 12x36, 14x36, 16x42, 22&38x48, 26&54x60, 30&60x60 Hamilton. Send for complete list of Engines, Boilers, Generators, Motors. Harold R. Wilson Machinery Co., St. Louis.

GAS ENGINE—One Foos vertical 15x20-in. three-cylinder producer-gas engine, 150 brake hp., speed 225 r.p.m., connected to S-5½-E, 100 kw., 250-volt, compound-wound, direct-current Western Electric generator with field rheostat; approximate weight, 49,000 lb.; good condition; very moderate use for about two years. F. S. 917, Power.

WE HAVE FOR SALE a practically new vertical MacIntosh & Seymour engine, high-pressure cylinder, 16 in. in diameter; low-pressure cylinder, 32 in. in diameter; stroke of engine, 42 in.; revolutions per minute, 125; indicated horsepower, 660 to 980; also heater, separator and condenser; total price, $7500, f.o.b. cars, Nashua, N. H. The Jackson Co., Nashua, N. H.

MISCELLANEOUS

PATENTS SECURED—C. L. Parker, Patents 904 G St. Washington, D. C.

ENGINEERS—Do you want to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so, address Monash-Younker Co., 1417 W. Jackson Blvd., Chicago, Ill.

WANTED—Additional capital for Lawrence Mfg. Co., lately incorporated to manufacture and exploit new inventions patented in the U. S., Canada and England; for particulars address: Lawrence Mfg. Co., Key West, Fla., or George Hiram Mann., 71 Wall St., New York.